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Indian Standard

STRUCTURED-WALL PLASTICS PIPING SYSTEMS FOR NON-PRESSURE DRAINAGE AND SEWERAGE — SPECIFICATION

PART 2 PIPES AND FITTINGS WITH NON-SMOOTH EXTERNAL SURFACE, TYPE B

ICS 23.040.20; 23.040.45; 91.140.80; 93.030

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B U R E A U   O F   I N D I A N   S T A N D A R D S
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NEW DELHI 110002

March 2013 **Price Group 12**

Plastic Piping Systems Sectional Committee, CED 50

FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Plastic Piping Systems Sectional Committee had been approved by the Civil Engineering Division Council.

This standard on structured wall plastic piping systems for non-pressure underground drainage and sewerage has been published in two parts. The other part in the series is:

Part 1 Pipes and fittings with smooth external surface, Type A

In the formulation of this standard considerable assistance has been derived from ISO 21138-1 and 3 : 2007 'Plastic piping systems for non-pressure underground drainage and sewerage—Structured-wall piping systems of unplasticized polyvinyl chloride (PVC-U), polypropylene (PP) and polyethylene (PE): Part 1 Material specifications and performance criteria for pipes, fittings and system and Part 3 Pipe and fittings with non-smooth external surface, Type B'. However, only corrugated wall construction pipes and fittings of polyethylene have been included as other type of pipes are not being manufactured in India at present. The test for low temperature installation performance — Impact resistance (staircase method) at –10° C has not been included due to the Indian climatic conditions. Provisions for adding calcium carbonate ($CaCO_3$) or talc to the virgin PE material has not been considered as this practice is not prevailing in India.

Piping systems conforming to this standard is resistant to corrosion by water with wide range of *p*H values, such as domestic waste water, surface water and ground water. If piping system conforming to this standard is to be used for chemically contaminated waste waters such as industrial discharges, chemical and temperature resistance must be taken into account. Guidance on the chemical resistance of PVC-U and PE materials is given in IS/ISO 10358 'Plastics pipes and fittings—Combined chemical-resistance classification table' (*under preparation*).

General guidance regarding laying and jointing including storage and handling for polyethylene pipes has been provided in IS 7634 (Part 2) : 1975 'Code of practice for plastic pipe work for potable water supplies: Part 2 Laying and jointing of polyethylene pipes'. However, some additional requirements for these pipes have been given at Annex A. There is no Indian Standard for the laying and jointing of PP pipes at present. PE and PP pipes belong to the same polyolefin's family. As such, IS 7634 (Part 2) may be used for PP pipes also.

Guidelines on structural design of thermoplastics pipelines have been provided in Annex B of the standard for information.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STRUCTURED-WALL PLASTICS PIPING SYSTEMS FOR NON-PRESSURE DRAINAGE AND SEWERAGE — SPECIFICATION

PART 2 PIPES AND FITTINGS WITH NON-SMOOTH EXTERNAL SURFACE, TYPE B

1 SCOPE

This standard (Part 2) specifies requirements for pipes and fittings with non-smooth external and smooth internal surface based on PE structured wall piping system for non-pressure underground drainage and sewerage.

It is applicable to PE or PP structured wall-pipes and fittings with or without integral sockets and with elastomeric sealing ring joints as well as welded or fused joints. This standard covers the pipes and fittings sizes from 75 mm to 1 200 mm nominal inside diameter.

NOTES

1 These pipes, fittings and the system can be used for highway drainage and surface water.

2 Other thermoplastic materials can be added *via* an addendum.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
2530 : 1963	Methods of test for polyethylene molding materials and polyethylene compounds
3400	Methods of test for vulcanized rubber:
(Part 2) : 2003	Part 2 Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD) (*third revision*)
4905 : 1968	Methods for random sampling
5382 : 1985	Specification for rubber sealing rings for gas mains, water mains and sewers (*first revision*)
7328 : 1992	High density polyethylene materials for moulding and extrusion — Specification (*first revision*)
12235	Thermoplastics pipes and fittings — Methods of test:
(Part 6) : 2004	Stress relief test
(Part 8)	Resistance to internal hydrostatic pressure,
(Sec 1) : 2004	Resistance to internal hydrostatic pressure at constant hydrostatic pressure (*first revision*)
(Sec 2) : 2004	Leak-tightness of elastomeric sealing ring type socket joints under positive internal pressure and with angular defection (*first revision*)
(Sec 3) : 2004	Leak-tightness of elastomeric sealing ring type socket joints under negative internal pressure and with angular defection (*first revision*)
(Part 9) : 2004	Resistance to external blows (impact resistance) at 0°C (round-the-clock method)
13360	Plastics — Methods of test:
(Part 2)	Sampling and preparation of test specimens,
(Sec 1) : 1992	Compression moulding test specimens of thermoplastics materials
(Sec 3) : 2000	Injection moulding of test specimens of thermoplastic materials — General principles and moulding of multipurpose and bar test specimens
16098 (Part 1) : 2013	Structured-wall plastics piping systems for non-pressure drainage and sewerage — Specification: Part 1 Pipes and fittings with smooth external surface, Type A

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Nominal Size (DN) — The numerical designation for the size of a pipe, other than a pipe designated by thread size, which is a convenient round number approximately equal to the manufacturing dimension, in millimetre.

3.2 Nominal Outside Diameter (d_n) — The specified outside diameter assigned to the nominal size, in millimetre.

3.3 Outside Diameter at Any Point (d_e) — The value of the measurement of the outside diameter of a pipe through its cross-section at any point of the pipe, rounded off to the next higher 0.1 mm.

3.4 Mean Outside Diameter (d_{em}) — The quotient of the outer circumference of a pipe and 3.142 (π) in any cross-section, rounded off to the next higher 0.1 mm.

3.5 Minimum Mean Outside Diameter ($d_{em, Min}$) — The minimum value of the mean outside diameter as specified for a given nominal size.

3.6 Maximum Mean Outside Diameter ($d_{em, Max}$) — The maximum value of the mean outside diameter as specified for a given nominal size.

3.7 Inside Diameter of a Socket (d_s) — The value of the measurement of the inside diameter of the socket at any point in any cross-section of the socket.

3.8 Mean Inside Diameter of a Socket (d_{sm}) — The arithmetical mean of four measurements taken at 45° to each other, of the inside diameter of the socket in the same cross-section of the socket.

3.9 Out-of-Roundness (Ovality) — The difference between the measured maximum and the measured minimum outside diameter in the same cross-section of the pipe.

3.10 Nominal Wall Thickness (e_a) — A numerical designation of the wall thickness of a component which is a convenient round number, approximately equal to the manufacturing dimension, in millimetre.

3.11 Wall Thickness at Any Point (e) — The value of the measurement of wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1 mm.

3.12 Minimum Wall Thickness at Any Point (e_{Min}) — The minimum value for the wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1 mm.

3.13 Maximum Wall Thickness at Any Point (e_{Max}) — The maximum value for the wall thickness at any point round the circumference of a pipe, rounded off to the next higher 0.1 mm.

3.14 Mean Wall Thickness (e_m) — The arithmetic mean of at least four measurements regularly spaced around the circumference and in the same cross-section of a pipe, including the measured minimum and measured maximum values of the wall thickness in that cross-section, rounded off to the next higher 0.1 mm.

3.15 Maximum Mean Wall Thickness ($e_{m, Max}$) — The maximum value for the mean wall thickness around the circumference of a component, as specified.

3.16 Construction Height (e_c) — Radial distance between the top of ribs or corrugation or in the case of Type A and Type B pipes and fittings, between the outside surface of wall and inside surface of wall.

3.17 Minimum Length of a Spigot ($l_{1, Min}$) — Minimum permitted value for the length of a spigot of a pipe or fitting.

3.18 Tolerance — The permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value.

3.19 Standard Dimension Ratio (SDR) — A numerical designation of a pipe series, which is a convenient round number approximately equal to the ratio of the minimum mean outside diameter, $d_{em, Min}$ and the minimum wall thickness at any point, e_{Min}

$$SDR = \frac{d_{em, Min}}{d_{Min}}$$

3.20 Nominal Ring Stiffness (SN) — A numerical designation, which is a convenient round number, of the ring stiffness in kN/m^2, indicating the minimum required ring stiffness of a pipe or fitting.

3.21 Structured Wall Pipes — Pipes which have an optimized design with regard to material usage to achieve the physical, mechanical and performance requirements of this standard.

3.22 Ring Flexibility — Ability of a pipe to resist diametric deflection without loss of structural integrity.

3.23 Virgin Material — Material in such form as granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessable or recyclable materials have been added.

3.24 Double Wall Corrugated (DWC) — Structured wall pipes with hollow annular profiled outer surface and a smooth inner surface.

3.25 Own Rework Material — Material prepared from rejected, unused pipes or the fittings, including trimmings from the production of pipes or fittings that will be reprocessed in a manufacturer's plant by a process such as extrusion or injection moulding and for which the complete formulation is known.

3.26 Tests

3.26.1 *Type Tests*

Tests carried out whenever a change is made in the composition or in the size/series in order to establish the suitability and the performance capability of the pipes and fittings.

3.26.2 *Acceptance Tests*

Tests are carried out on samples taken from a lot for the purpose of acceptance of the lot.

4 SYMBOLS

A	—	length of engagement, or maximum pull-out whilst maintaining tightness
D_i	—	socket inside diameter
$D_{im, Min}$	—	minimum mean inside diameter of a socket
d_e	—	outside diameter
d_{em}	—	mean outside diameter
d_i	—	inside diameter
d_{im}	—	mean inside diameter
e	—	wall thickness (at any point)
e_c	—	construction height
e_2	—	wall thickness of the socket
e_3	—	wall thickness of the groove
e_4	—	wall thickness of the inside layer (waterway wall thickness)
F	—	distance from the spigot end to the effective sealing point
l	—	effective length of a pipe
$L_{1, Min}$	—	minimum length of a spigot
Z_1	—	design length of a fitting
Z_2	—	design length of a fitting
Z_3	—	design length of a fitting
α	—	nominal angle of a fitting
l_1	—	length of spigot

5 COMPOSITION OF THE MATERIAL

5.1 The material from which the pipe is produced shall consist substantially of polyethylene (PE) or polypropylene (PP) to which may be added those additives that are needed to facilitate the manufacture of these pipes and fittings conforming to requirements of this standard as per Tables 1, 2, 3 and 4.

5.2 Rework Material

Clean, reprocessable material generated from a manufacturer's own production according to this standard may be used if it is derived from the same raw material as used for the relevant production. Reprocessable material obtained from external sources and recyclable material shall not be used.

6 DESIGNATION OF WALL CONSTRUCTIONS AND EXAMPLES OF TYPICAL JOINING METHODS

6.1 Wall Construction Designated as Type B

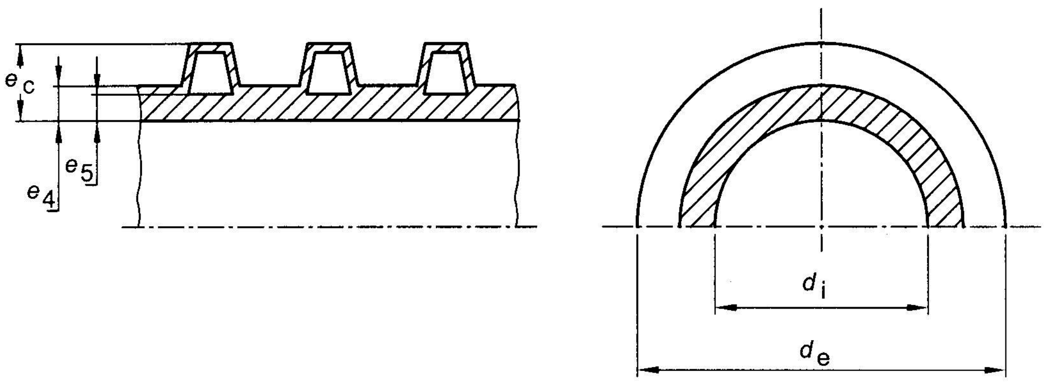
6.1.1 *Outside Profiled and Inside Smooth Profile Section*

A pipe or fitting with a smooth internal and profiled external surface forming a finished double walled profile shall come under this standard.

Typical example of corrugated wall construction is shown in Fig. 1.

6.2 Designation

Pipes and fittings will be designated on the basis of its material/structure wall construction/nominal ID (DN/ID)/nominal ring stiffness, such as PE/DWC/ID/SN.



NOTE — The figures are schematic sketches only to indicate the relevant dimensions. They do not necessarily represent the manufactured components.

FIG. 1 TYPICAL EXAMPLES OF NON-SMOOTH EXTERNAL PROFILED (CORRUGATED WALL) CONSTRUCTION

Table 1 Material Characteristics for PE Material in Granules Form
(*Clause* 5.1)

Sl No.	Characteristics	Requirements	Test Parameters	Method of Test, Ref to	
				Annex	IS
(1)	(2)	(3)	(4)	(5)	(6)
i)	Base density	≥ 0.930 g/cc	In accordance with IS 7328	—	7328
ii)	Melt flow rate (MFR)[1)]	≤ 1.6 g/10 min	a) Temperature — 190°C b) Loading mass — 5 kg	—	2530
iii)	Thermal stability (oxidation induction test, OIT)	≥ 20 min	Temperature — 200°C	C	—

[1)] For PE rotational moulded fittings, MFR values should be between 3g/10 min and 16g/10 min.

Table 2 Material Characteristics for PE Material in Pipe Form
(*Clause* 5.1)

Sl No.	Characteristics	Requirements	Test Parameters	Method of Test, Ref to
(1)	(2)	(3)	(4)	(5)
i)	Resistance to internal pressure, 165 h[1)]	No failure during the test period	a) Test temperature — 80°C b) Orientation — Free c) Number of test pieces — 3 d) Circumferential stress — 4.0 MPa e) Conditioning period — 27 ± 2°C f) Type of test — Water-in-water g) Test period — 165 h	IS 12235 (Part 8/Sec 1)
ii)	Resistance to internal pressure 1 000 h[1)]	No failure during the test period	a) Test temperature — 80°C b) Orientation — Free c) Number of test pieces — 3 d) Circumferential stress — 2.8 MPa e) Conditioning period — 27 ± 2°C f) Type of test — Water-in-water g) Test period — 1 000 h	IS 12235 (Part 8/Sec 1)

[1)] For the above PE compound, this test shall be carried out in the form of a solid wall pipe made from the relevant grade of material.

Table 3 Material Characteristics for PP Material in Granules Form
(*Clause* 5.1)

Sl No.	Characteristics	Requirements	Test Parameters	Method of Test, Ref to	
				Annex	IS
(1)	(2)	(3)	(4)	(5)	(6)
i)	Melt flow rate (MFR)	≤ 1.5g/10 min	a) Temperature — 230°C b) Loading mass — 2.16 kg	—	2530
ii)	Thermal stability (oxidation induction test, OIT)[1)]	≥ 8 min	Temperature — 200°C	C	—

[1)] The requirement is only valid for pipes and fittings intended to be jointed in the field by fusing or welding.

6.3 Dimension of Pipes and Fittings

6.3.1 *Diameter of Pipe*

The internal diameter (DN/ID) shall be as per Table 5. Other nominal sizes, falling within the range of Table 5 are also permitted.

For DN/IDs not specified in Table 5, the minimum inside diameter, $d_{im,\,Min}$, shall be linearly interpolated between the adjacent values specified in Table 5.

6.3.2 *Lengths of Pipe*

The effective length of pipe, l shall be not less than that specified by the manufacturer when measured as shown in Fig. 2.

6.3.3 *Diameters of Pipes and Spigots of Pipes or Fittings*

The nominal sizes and minimum mean inside diameter for DN-ID series are specified in Table 2. The outside diameters of the DN-ID series pipes and spigots

Table 4 Material Characteristics for PE Material in Pipe Form
(*Clause* 5.1)

Sl No.	Characteristics	Requirements	Test Parameters			Method of Test, Ref to
(1)	(2)	(3)	(4)			(5)
i)	Resistance to internal pressure, 140 h[1)]	No failure during the test period	a) Test temperature b) Orientation c) Number of test pieces d) Circumferential stress e) Conditioning period f) Type of test g)Test period	— — — — — —	80°C Free 3 4.2 MPa 27 ± 2°C Water-in-water 140 h	IS 12235 (Part 8/Sec 1)
ii)	Resistance to internal pressure 1 000 h[1)]	No failure during the test period	a) Test temperature b) Orientation c) Number of test pieces d) Circumferential stress e) Conditioning period f) Type of test g) Test period	— — — — — — —	95°C Free 3 2.5 MPa 27 ± 2°C Water-in-water 1 000 h	IS 12235 (Part 8/Sec 1)

[1)] For the above PP compound, this test shall be carried out in the form of a solid wall pipe made from the relevant grade of material.

Table 5 Nominal Sizes, Minimum Mean Inside Diameters, Thickness of Inside Layers and Socket Length
(*Clauses* 6.3.1, 6.3.5.1.4, 6.3.5.1.5 *and* 6.3.5.2)

Sl No.	DN/ID Series		Minimum Wall Thickness		Socket[1)] Length
	DN/ID	$d_{im, Min}$ mm	$e_{4, Min}$ mm	$e_{5, Min}$ mm	A_{Min} mm
(1)	(2)	(3)	(4)	(5)	(6)
i)	75	71	1.0	0.85	27
ii)	100	95	1.0	1.0	32
iii)	125	120	1.2	1.0	38
iv)	135	130	1.2	1.0	39
v)	150	145	1.3	1.0	43
vi)	170	165	1.4	1.0	48
vii)	200	195	1.5	1.1	54
viii)	225	220	1.7	1.4	55
ix)	250	245	1.8	1.5	59
x)	300	294	2.0	1.7	64
xi)	400	392	2.5	2.3	74
xii)	500	490	3.0	3.0	85
xiii)	600	588	3.5	3.5	96
xiv)	800	785	4.5	4.5	118
xv)	1 000	985	5.0	5.0	140
xvi)	1 200	1 185	5.0	5.0	162

[1)] For selection of A_{Min} requirements for socket, refer to the pipe material and construction. For pipes longer than 6 m it is recommended that one produce a larger A_{Min} than is specified in this table.

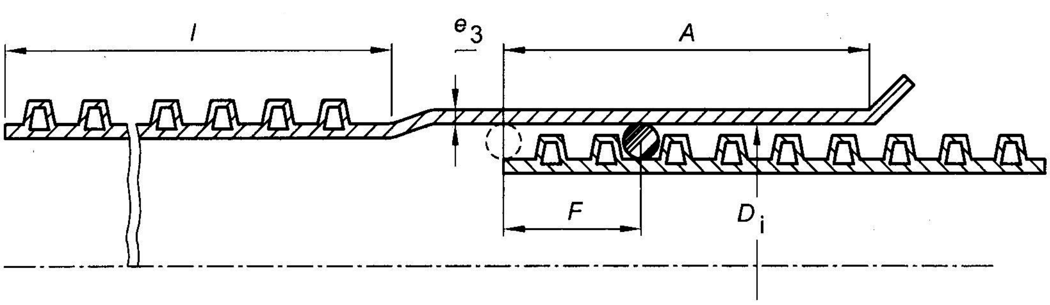


FIG. 2 TYPICAL ASSEMBLY OF PIPING SYSTEM WITH ELASTOMERIC SEALING RING ON SPIGOT

intended to have jointing dimensions as pipes and/or fittings according to this standard shall comply with the outside diameters and tolerances as specified by the manufacturer. However, the guidelines for pipes, spigots and fittings not intended to have jointing dimensions as pipes and/or fittings according to this standard, the tolerance of the outside diameter of pipes and spigots, fittings shall be:

$$d_{em, Min} \leq 0.994 \times d_e$$

$$d_{em, Max} \geq 1.003 \times d_e$$

where

d_e = nominal size of outside diameter as specified by the manufacturer of a DN-ID designated pipe. The results are to be rounded to the next higher 0.1 mm.

6.3.4 *Diameters and Jointing Dimensions of Sockets and Spigots*

6.3.4.1 *Joints with the elastomeric sealing ring positioned in the socket of pipes or fittings*

For these pipes, the requirement regarding the socket and spigot dimension, A_{Min} specified in Table 2 applies.

In the case where other nominal sizes other than those specified in Table 2 are selected, the requirements regarding the socket dimension A_{Min} shall be linearly interpolated between the adjacent values specified in Table 2. The minimum mean inside diameter of socket, $D_{i, Min}$ shall be equal to $d_{e, Max}$.

6.3.5 *Wall Thickness*

6.3.5.1 *Wall thickness of sockets and joint design requirements*

6.3.5.1.1 *General*

In addition to the minimum required wall thickness of sockets and spigots as specified below, their ring stiffness, when determined in accordance with Table 10 shall conform to the following equation:

$$S_{socket} + S_{spigot} \geq SN_{pipes}$$

For the test it is permitted to use cut-off straight socket and spigot parts even if they do not conform to the length requirements specified in Annex C of IS 16098 (Part 1).

6.3.5.1.2 *Spigot*

When the spigot has the same design as the pipe, the wall thickness requirements for the corresponding pipe dimension and construction shall apply.

In the case of a solid plain spigot design, the wall thickness, e shall conform to values given below:

a) $d_e \leq 500$: $d_e/33$, but not less than 4.2 mm.

b) $d_e > 500$: 15.2 mm.

NOTE — The values shall be calculated to the second decimal place and rounded to the next higher 0.1mm.

6.3.5.1.3 *Sockets heat formed on the pipes*

When a socket is heat formed on a pipe segment the following is permitted.

For joints with the sealing ring positioned on the pipe, a reduction of the wall thickness e_4 and e_5, as applicable, to 75 percent. The manufacturer shall specify the reference value for the wall thickness.

6.3.5.1.4 *Structured wall designed sockets with stiffness ≥ 4 kN/m²*

For structured-wall designed sockets, the wall thickness e_4 and e_5 as applicable, shall comply with the requirements given in Table 5.

6.3.5.1.5 *Other sockets with stiffness < 4 kN/m²*

The thickness of the inner wall of the socket shall be at least $1.5 \times e_4$, as specified in Table 5.

6.3.5.2 *Injection moulded fittings*

The minimum wall thickness in the body of injection moulded fittings, $e_{4\,Min}$, for DN/ID ≤ 300 mm shall be 2.0 mm. For larger sizes, it shall conform to the requirements for $e_{4\,Min}$ as specified in Table 5.

The construction height of the body wall, e_c for injection moulded fittings up to 200 mm actual outside diameter of pipes in the DN-ID series shall be at least as specified for e_{Min} as below:

Nominal Size DN/ID	e_{Min} mm
75	4.0
100	4.8
125	5.8
135	6.2
150	7.0
170	7.7

In the case of ID series fittings, the calculations shall be based on the actual diameter of the corresponding pipes.

The jointing design including socket and spigot dimensions, shall conform to **6.3.5.1**.

6.3.5.3 *Fabricated fittings*

The wall thickness of the body of fittings fabricated from pipes shall conform to the requirements of the corresponding pipes. Wall thickness reduction due to the process is permitted provided the requirements in

Table 12 are satisfied. The jointing design including socket and spigot dimensions, shall conform to **6.3.5.1**.

6.3.5.4 *Rotational moulded fittings*

The minimum wall thickness in the body of rotational moulded fitting, $e_{4\ Min}$ shall be 1.25 times the values specified for the injection moulded fittings, rounded to the next higher 0.1 mm.

If a rotational moulded fitting has a solid plain spigot and/or socket, the minimum required wall thickness e_1, e_2 and e_3 as applicable shall be 1.25 times the values derived from **6.3.5**.

The socket and spigot dimensions shall comply with **6.3.5.1**.

6.4 Types of Fittings

6.4.1 *General*

The following types of fittings are permitted. Other designs of fittings, including all sockets and all spigots, are also permitted.

a) Bends, swept and unswept angle (*see* Fig. 3 and Fig. 4).

NOTE — Preferred nominal angles, α, are 15°, 22.5°, 30° and 45°.

b) Couplers (*see* Fig. 5).

c) Reducers (*see* Fig. 6).

d) Branches and reducing branches, swept and unswept entry (*see* Fig. 7).

NOTE — Preferred nominal angles, α, are 45° and between 87.5° and 90°.

e) Plugs (*see* Fig. 8).

NOTES

1 Figures 3 to 8 are for reference only and do not necessarily represent manufactured components.

2 The design lengths (s) (Z lengths) of the fittings shall be declared by the manufacturer.

3 The minimum length, L_1 of the spigots shall be such that it passes the ring seal by at least 10 mm.

7 PHYSICAL CHARACTERISTICS FOR PIPES AND FITTINGS

7.1 Appearance

The structured outer layer of finished pipes and fittings shall be uniformly corrugated. The inner layer shall

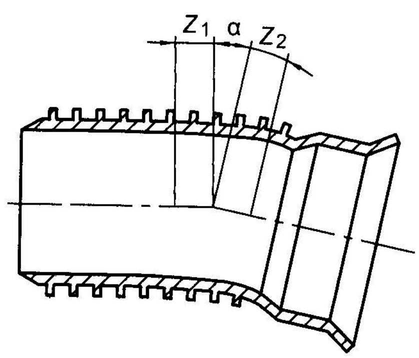


FIG. 3 EXAMPLE OF AN UNSWEPT BEND

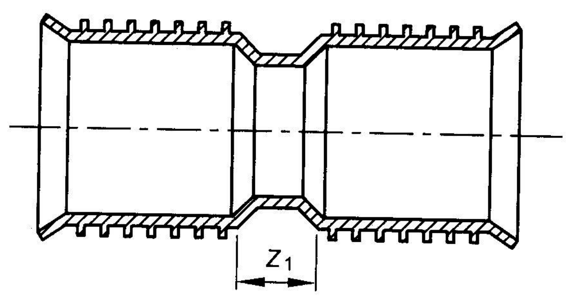


FIG. 5 EXAMPLE OF A COUPLER

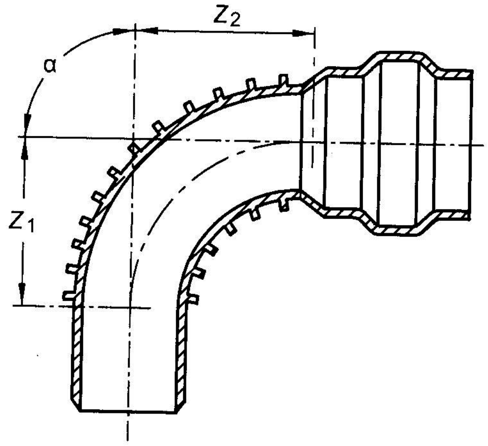


FIG. 4 EXAMPLE OF A SWEPT BEND

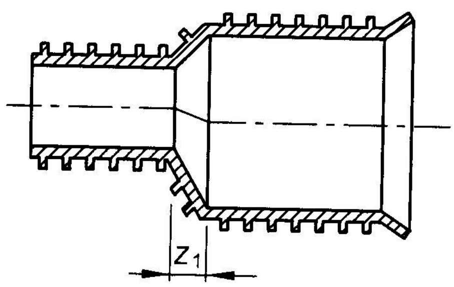


FIG. 6 EXAMPLE OF A REDUCER

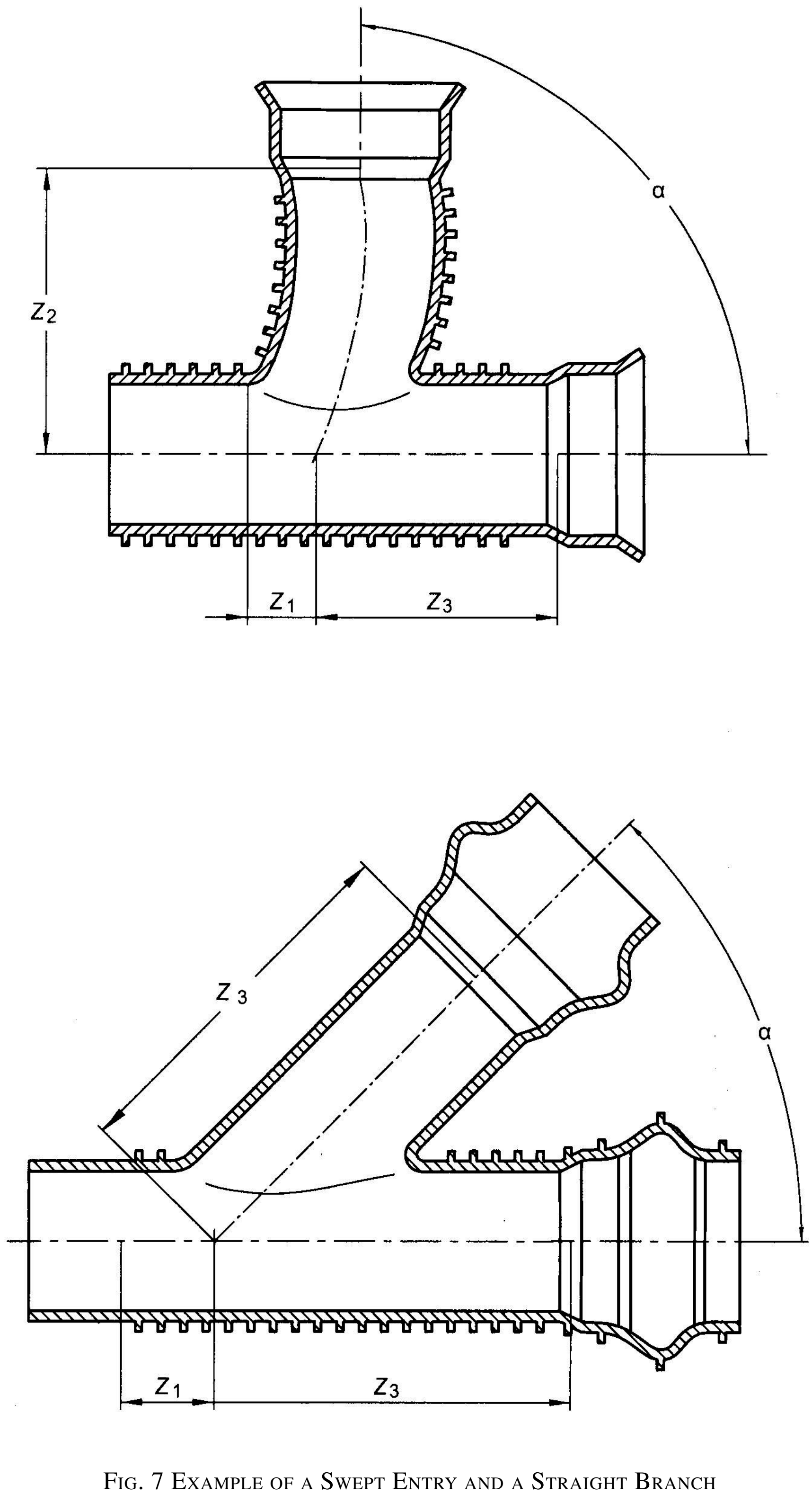


FIG. 7 EXAMPLE OF A SWEPT ENTRY AND A STRAIGHT BRANCH

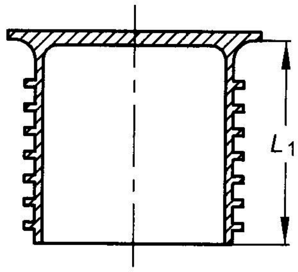


FIG. 8 EXAMPLES OF A PLUG

be smooth and plain. Both layers shall be free from any visual defects such as cracks, blisters, foreign inclusions and any other visual irregularities which may cause harm to its construction integrities. The inner surface may reflect slight shallow undulations.

7.1.1 *Colour of Finished Pipes*

The inner and outer layer of pipes and fittings shall be coloured throughout. The outside layer of pipes and fittings should preferably be black, orange brown or grey.

7.2 When tested in accordance with the test method specified in Table 6 and Table 7 using the indicated parameters, the pipes shall have physical characteristics conforming to the requirements given in Table 6 and Table 7.

7.3 When tested in accordance with the test method specified in Table 8 and Table 9 using the indicated parameters, the fitting shall have physical characteristics conforming to the requirements as given in Table 8 and Table 9.

Table 6 Physical Characteristics of PE Pipes
(*Clause* 7.2)

Sl No.	Characteristic	Requirements	Test Parameters			Method of Test, Ref to
(1)	(2)	(3)	(4)			(5)
i)	Resistance to heating oven test	The pipe shall show no delamination, cracks or bubbles	Temperature	—	110 ± 2°C	IS 12235 (Part 6)
			Immersion time for [1]:			
			a) $e \le 8$ mm	—	30 min	
			b) $e > 8$ mm	—	60 min	

[1] For the wall thickness, *e*, the maximum measured wall thickness of the pipe excluding e_c shall be taken.

Table 7 Physical Characteristics of PP Pipes
(*Clause* 7.2)

Sl No.	Characteristic	Requirements	Test Parameters			Method of Test, Ref to
(1)	(2)	(3)	(4)			(5)
i)	Resistance to heating, oven test	The pipe shall show no delamination, cracks or bubbles [1]	Test temperature	—	150 ± 2°C	IS 12235 (Part 6)
			Immersion time for [1]:			
			a) $e \le 8$ mm	—	30 min	
			b) $e > 8$ mm	—	60 min	

[1] For the wall thickness, *e*, the maximum measured wall thickness of the pipe excluding e_c shall be taken.

Table 8 Physical Characteristics of PE Injection-Moulded Components
(*Clause* 7.3)

Sl No.	Characteristic	Requirements	Test Parameters			Method of Test, Ref to
(1)	(2)	(3)	(4)			(5)
i)	Effect of heating [1]	The components shall show no delaminations, cracks or bubbles [2]	Test temperature	—	110 ± 2°C	Annex D
			Heat tube time for [3]:			
			a) $e \le 3$ mm	—	15 min	
			b) 3 mm < $e \le 10$ mm	—	30 min	
			c) 10 mm < $e \le 20$ mm	—	60 min	

[1] Only applicable to injection moulded fittings and injection moulded components for fabricated fittings.
[2] The depth of cracks, delamination or blisters shall not be more than 20 percent of the wall thickness around the injection point(s). No part of the weld line shall open to a depth of more than 20 percent of the wall thickness.
[3] For the wall thickness, *e* the maximum measured wall thickness of the fitting excluding e_c shall be taken.

Table 9 Physical Characteristics of PP Injection-Moulded Components
(*Clause* 7.3)

Sl No.	Characteristic	Requirements	Test Parameters		Method of Test, Ref to
(1)	(2)	(3)	(4)		(5)
i)	Effect of heating[1)]	The components shall show no delaminations, cracks or bubbles[2)]	a) Test temperature b) Heat tube time[3)]	— 150 ± 2°C — As per Table 26	Annex D

1) Only applicable to injection moulded fittings and injection moulded components for fabricated fittings.
2) The depth of cracks, delamination or blisters shall not be more than 20 percent of the wall thickness around the injection point(s). No part of the weld line shall open to a depth of more than 20 percent of the wall thickness.
3) For the wall thickness, *e*, the maximum measured wall thickness of the fitting excluding e_c shall be taken.

8 MECHANICAL CHARACTERISTICS

8.1 Mechanical Characteristics of Pipes

8.1.1 *General*

The pipes shall be designated in the following nominal ring stiffness classes (SN):

a) DN ≤ 500 : SN 4, SN 8 or SN 16
b) DN > 500 : SN 2, SN 4, SN 8 or SN 16

For DN ≤ 500, the manufacturer's guaranteed minimum stiffness between the SN values, of a component may be used for calculation purposes only. Such pipes shall be classified and marked as the next lower stiffness class.

When tested in accordance with the test method specified in Table 10 using the indicated parameters, the pipe shall have mechanical characteristics conforming to the requirements given in Table 10.

8.1.2 *Ring Flexibility*

When tested in accordance with the test method described in Table 10 using the indicated parameters, and visually inspected without magnification, requirements in (a) and (b) shall be satisfied during the test and requirements (c) to (d) shall be satisfied after the test.

a) There shall be no decrease of the measured force;
b) There shall be no cracking in any part of the wall structure;
c) There shall be no wall delamination except possible delamination between the outside and inside wall of double wall pipes occurring in reduced welding zone in the ends of test piece. Process aiding profile of material other than the pipe material (*see* Fig. 1) is not subject to this requirement;
d) There shall be no other types of rupture in the test piece; and
e) Permanent buckling in any part of the structure of the pipe wall including depressions and craters, shall not occur in any direction.

8.2 Mechanical Characteristics of Fittings

8.2.1 *General*

The fittings shall be designated in one of the following nominal stiffness classes (SN):

a) DN ≤ 500 : SN 4, SN 8 or SN 16
b) DN > 500 : SN 2, SN 4, SN 8 or SN 16

When tested in accordance with test methods specified in Table 11 using the indicated parameters, the fitting shall have mechanical characteristics conforming to the requirements given in Table 11.

NOTE — For DN ≥ 500, the manufacturer's guaranteed minimum stiffness, between the SN nominal values of a component, can be used for calculation purpose.

8.2.2 *Impact Strength of Injection-Moulded and Fabricated Fittings*

For this test, fittings shall be conditioned for 30 min at a temperature of 0 ± 1°C. Within 10 s after the conditioning treatment, five fittings of each diameter and type shall be dropped freely in various positions on to a flat concrete floor from a height of 1 ± 0.05 m.

If one fitting is damaged the test shall be repeated with five other fittings. None of these last five fittings shall be damaged.

NOTE — In the context of this test, damage means any visible split or any complete breakage in the body of the fitting. Surface scratches, scuffing, or chipping of edge which may occur in the test does not constitute damage.

8.3 Joints

Elastomeric sealing rings shall be free from substances that can have a detrimental effect on the pipes or fittings used in conjunction with pipes.

The design of the profile and dimensions of the sealing ring is left to the manufacturer, as long as the pipe with the sealing ring meets the requirements of this standard. Where the design of the socket is such that the ring is

Table 10 Mechanical Characteristics of Pipes
(*Clause* 8.1.1)

Sl No. (1)	Characteristic (2)	Requirements (3)	Test Parameters (4)		Method of Test, Ref to (5)
i)	Ring stiffness	≥ relevant SN	In accordance with Annex C of IS 16098 (Part 1)		As per Annex C of IS 16098 (Part 1)
ii)	Impact strength	TIR ≤ 10 percent	a) Type of striker b) Mass of striker for: 1) $d_{im,Max} \leq 100$ mm 2) $100 < d_{im,Max} \leq 125$ 3) $125 < d_{im,Max} \leq 160$ 4) $160 < d_{im,Max} \leq 200$ 5) $200 < d_{im,Max} \leq 250$ 6) $200 < d_{im,Max} \leq 315$ 7) $d_{im,Max} > 315$ c) Fall height of striker: 1) $d_{im,Max} \leq 100$ 2) $d_{im,Max} > 100$	: *d* 90 : 0.5 kg : 0.8 kg : 1.0 kg : 1.6 kg : 2.0 kg : 2.5 kg : 3.2 kg : 1 600 mm : 2 000 mm	IS 12235 (Part 9)
iii)	Ring flexibility	In accordance with **8.1.2** at 30 percent of d_{em}	Deflection position of test piece	30 percent mould split line, when applicable, at 0°, 45° and 90° from the upper plate	As per Annex D of IS 16098 (Part 1)
iv)	Creep ratio	≤ 4 at 2 year extrapolation	As per Annex E of IS 16098 (Part 1)		As per Annex E of IS 16098 (Part 1)

Table 11 Mechanical Characteristics of Fittings
(*Clause* 8.2.1)

Sl No. (1)	Characteristic (2)	Requirements (3)	Test Parameters (4)		Method of Test, Ref to (5)
i)	Stiffness[1)]	≥ relevant SN	Annex C of IS 16098 (Part 1)		Annex C of IS 16098 (Part 1)
ii)	Impact test	No cracks through the wall; jumped-off sealing elements shall be able to be restored in correct position manually	See 8.2.2		See 8.2.2
iii)	Mechanical strength or flexibility[2)]	No signs of splitting cracking, separation and/or leakage	a) Test period b) Minimum moment for: 1) $d_e \leq 250$ mm 2) $d_e > 250$ mm c) Minimum displacement	: 15 min : $0.15(DN)^3 \times 10^{-6}$ kNm : 0.01(DN) kNm or : 170 mm	Annex E

[1)] When a fitting in accordance with this standard has the same wall construction as a corresponding pipe, the stiffness of the fitting, because of its geometry, is equal to or greater than that of the pipe. Such fittings can be classified with the same stiffness class as that pipe without testing the stiffness.

[2)] Only for fabricated fittings made from more than one piece (a sealing ring retaining component is not considered as a piece) or when the minimum wall thickness in the body, $e_{4,\,Min}$ is less than ($0.9 \times d_{em}$ /33).

not firmly fixed in position, the housing for the ring shall be so designed as to minimize the possibility of the ring being dislodged during insertion of the pipe (or spigot or fitting) to complete the joint.

Elastomeric sealing rings shall be in accordance with one of the type (Type 1 to Type 6) of IS 5382. The manufacturer should specify the type of sealing ring (namely Type 1, 2, 3, 4, 5 or 6) that is being offered.

NOTE — A test report or conformity certificate may be obtained from the manufacturer of the sealing ring for conformity to IS 5382.

9 PERFORMANCE REQUIREMENTS

When tested in accordance with the test methods specified in Table 12, using the indicated parameters, the joints and the system shall have characteristics conforming to the requirements given in Table 12.

Table 12 Performance Requirements
(*Clause* 9)

Sl No.	Characteristics	Requirements	Test Parameters		Method of Test, Ref to Annex	Method of Test, Ref to IS
(1)	(2)	(3)	(4)		(5)	(6)
i)	Tightness of elastomeric ring seal joint	a) No leakage	a) Temperature	: 27±2°C		12235 (Part 8/ Sec 2 and Sec 3)
			b) Joint deflection for:			
			1) $d_e \le 315$ mm	: 2°		
			2) 315 mm $< d_e \le 630$ mm	: 1.5°		
			3) 630 mm $< d_e$	: 1°		
			c) Water pressure	: 5 kPa (0.05 bar)		
		b) No leakage	Water pressure	: 50 kPa (0.5 bar)		
		c) ≤ –27 kPa (–0.27 bar)	Air pressure	: –30 kPa (–0.3 bar)		
ii)	Water-tightness[1)]	No leakage	a) Water pressure	: 50 kPa (0.5 bar)	F	
			b) Duration	: 1 min		
iii)	Resistance to combined temperature cycling and external loading[2)]	See footnote[3)]	a) For $d_{im} \le 160$ mm :	: As per Method A of Annex G	G	
			b) For $d_{im} > 160$ mm:	: As per Method B of Annex G		

1) Only for fabricated fittings made from more than one piece. A sealing ring retaining component is not considered as a piece.
2) Only for components with DN/ID ≤ 300 mm.
3) The following requirements shall apply:

a) Vertical deformation	:	≤ 9 percent
b) Deviation from surface evenness	:	≤ 3 mm
c) Radius of bottom	:	≥ 80 percent of original
d) Opening of weld line	:	≤ 20 percent of wall thickness
e) Tightness at 35 kPa (0.35 bar)/15 min	:	no leakage allowed.

10 SAMPLING, FREQUENCY OF TESTS AND CRITERIA FOR CONFORMITY

10.1 Acceptance Test

10.1.1 Acceptance tests are carried out on sample selected from a lot (*see* **10.3.1**) for the purpose of acceptance of the lot in accordance with Table 13 (for pipes) and Table 14 (for fittings).

10.2 Type Test

10.2.1 Type tests are intended to prove the suitability and performance of a new technique or a new size of a pipe. Type testing shall be in accordance with Tables 15 to 18, as applicable. All tests are required to be carried out either in an in-house laboratory or at an authorized third party laboratory.

10.3 Sampling

10.3.1 *Lot*

All pipes of the same size, same grade and manufactured essentially under similar conditions shall constitute a lot. These pipes shall be selected at random from the lot and in order to ensure the randomness of selection, a random number table shall be used. For guidance and use of random number tables, IS 4905 may be referred. In the absence of a random number table, the procedure given in Table 19 may be adopted.

10.3.2 Starting from any pipe in the lot, count them as 1, 2, 3, 4, etc, up to *r* and so on where *r* is the integral part of *N*/*n*, *N* being the number of pipes in the lot and *n* is the number of pipes in the sample. Every *r*th pipe so counted shall be drawn so as to constitute the required sample size.

The number of pipes given for the first sample in col 4 of Table 19 shall be examined for dimensional and visual requirements. A pipe failing to satisfy any of these requirements shall be considered as defective. The lot shall be deemed to have satisfied these requirements, if the number of detectives found in the first sample are less than or equal to the corresponding acceptance number given in col 6 of Table 19. The lot shall be deemed not to have met these requirements, if the number of detectives found in the first sample is greater than or equal to the corresponding rejection numbers given in col 7 of Table 19.

If, however, the number of detectives found in the first sample lies between the corresponding acceptance and rejection numbers given in col 6 and col 7 of Table 19,

Table 13 Acceptance Tests for Pipes
(*Clause* 10.1.1)

Sl No. (1)	Description of Test (2)	Requirement, Ref to Clause (3)	Sample Size (4)
i)	Visual appearance, finish and colour	7.1 and 7.1.1	See Table 19
ii)	Dimensions	6.3	See Table 19
iii)	Melt flow rate	5.1	See Table 20
iv)	Base density	5.1	See Table 20
v)	Ring stiffness	8.1.1	See Table 20
vi)	Ring flexibility	8.1.2	See Table 20
vii)	Impact test	8.1.1	See Table 20
viii)	Resistance to heating, oven test	7.2	See Table 20

Table 14 Acceptance Tests for Fittings
(*Clause* 10.1.1)

Sl No. (1)	Description of Test (2)	Requirement, Ref to Clause (3)	Sample Size (4)
i)	Visual appearance, finish and colour	7.1 and 7.1.1	See Table 19
ii)	Dimensions	6.3	See Table 19
iii)	Ring stiffness	8.2.1	See Table 20
iv)	Impact test	8.2.2	See Table 20
v)	Effect of heating	7.3	See Table 20

Table 15 Type Test for PE Pipes
(*Clause* 10.2.1)

Sl No. (1)	Tests (2)	Requirement, Ref to Clause (3)	Sample Size (4)
i)	Resistance to internal hydrostatic pressure for 165 h at 4 MPa	5.1	See Table 20
ii)	Resistance to internal hydrostatic pressure for 1 000 h at 2.8 MPa	5.1	See Table 20
iii)	Creep ratio	8.1.1	See Table 20
iv)	Thermal stability (Oxidation induction test)	5.1	See Table 20
v)	Water tightness test	9.0	See Table 20
vi)	Tightness of elastomeric ring seal joint	9.0	See Table 20
vii)	Resistance to combined temperature cycling and external loading	9.0	See Table 20

Table 16 Type Test for PE Fittings
(*Clause* 10.2.1)

Sl No. (1)	Tests (2)	Requirement, Ref to Clause (3)	Sample Size (4)
i)	Thermal stability (Oxidation induction test)	5.1	See Table 11
ii)	Water tightness test	9.0	See Table 11
iii)	Flexibility	8.2.1	See Table 11

Table 17 Type Test for PP Pipes
(*Clause* 10.2.1)

Sl No. (1)	Tests (2)	Requirement, Ref to Clause (3)	Sample Size (4)
i)	Resistance to internal hydrostatic pressure for 165 h at 4.2 MPa	5.1	See Table 20
ii)	Resistance to internal hydrostatic pressure for 1 000 h at 2.5 MPa	5.1	See Table 20
iii)	Creep ratio	8.1.1	See Table 20
iv)	Thermal stability (Oxidation induction test)[1)]	5.1	See Table 20
v)	Water tightness test	9.0	See Table 20
vi)	Tightness of elastomeric ring seal joint	9.0	See Table 20
vii)	Resistance to combined temperature cycling and external loading	9.0	See Table 20

[1)] The requirement is only valid for pipes intended to be jointed in field by fusing or welding.

Table 18 Type Test for PP Fittings
(*Clause* 10.2.1)

Sl No. (1)	Tests (2)	Requirement, Ref to Clause (3)	Sample Size (4)
i)	Thermal stability (Oxidation induction test)[1)]	5.1	See Table 20
ii)	Water tightness test	9.0	See Table 20
iii)	Flexibility	8.2.1	See Table 20

[1)] The requirement is only valid for pipes intended to be jointed in field by fusing or welding.

Table 19 Scale of Sampling for Dimensional and Visual Requirements
(*Clause* 10.3.1)

Sl No. (1)	No. of Pipes in the Lot (2)	Sample No. (3)	Sample Size (4)	Cumulative Sample Size (5)	Acceptance No. (6)	Rejection No. (7)
i)	Up to 1 000	First	13	13	0	2
		Second	13	26	1	2
ii)	1 001 to 3 000	First	20	20	0	2
		Second	20	40	1	2
iii)	3 001 to 10 000	First	32	32	0	3
		Second	32	64	3	4
iv)	10 001 and above	First	50	50	1	4
		Second	50	100	4	5

the second sample of the size given in col 4 of Table 19 shall be taken and examined for these requirements. The lot shall be considered to have satisfied these, requirements, if the number of detectives found in the cumulative sample is less than or equal to the corresponding acceptance number given in col 6 of Table 19; otherwise not.

10.4 Conformance

The lot having satisfied dimensional and visual requirements shall be tested for other requirements with the sample size selected as per Table 20 from the lot. If the first sample drawn fails the tests, re-sampling should be done from the lot which has satisfied the dimensional and visual requirements. The lot shall be considered to have met the requirements of these tests, if none of these samples tested fails.

Table 20 Scale of Sampling for Tests Other than Visual and Dimensional Requirements

Sl No.	No. of Pipes in Lot	Sample Size for Sizes Less than or Equal to 500 mm ID	Sample Size for Sizes Greater than 500 mm ID
(1)	(2)	(3)	(4)
i)	Up to 1 000	2	1
ii)	1 001 to 3 000	3	2
iii)	3 001 and above	4	3

11 MARKING

11.1 General

Marking shall be labelled, printed or formed directly on the pipe or fitting, in such a way that after storage, weathering and handling the legibility shall be maintained. Marking shall not initiate cracks or other types of defects which adversely influence the performance of the pipes or the fitting.

11.2 Minimum Required Marking

11.2.1 *Pipes*

Each pipes shall be marked at intervals of maximum 3 m, at least once per pipe, with the following information:

a) Manufacturer's name/Trade-mark;
b) Diameter series, nominal size;
c) Stiffness class;
d) Material; and
e) Lot number/batch number containing information regarding period of manufacture.

11.2.2 *Fittings*

Each fitting shall be marked with the following information:

a) Manufacturer's name/Trade-mark;
b) Diameter series, nominal size;
c) Nominal angle;
d) Stiffness class;
e) Material; and
f) Lot number/batch number containing information regarding period of manufacture.

11.3 BIS Certification Marking

Each pipe or fittings may also be marked with the Standard Mark.

11.3.1 The use of the Standard mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Foreword*)

TRANSPORTATION, HANDLING, INSTALLATION AND JOINTING

A-1 TRANSPORTATION

The arrangement of loading the pipes in a telescopic manner is advised, that is, smaller diameters inserted into the next higher sizes of pipes up to the height of 2.5 m in a truck. While loading the pipes into the truck, care should be taken that the spigot/coupler end should be arranged alternatively in the corresponding layer so as to avoid the damage to the coupling/socket-end.

A-2 HANDLING

Following recommendations shall be followed while handling the pipes:

a) Pipes shall be smoothly lowered to the ground.
b) Pipes should not be dragged against the ground to avoid the damages to the coupler/ pipes.

c) 900 mm and larger diameter pipes are carried with slings at two points spaced approximately at 3 m apart.

d) For smaller diameters (450 mm to 900 mm, both exclusive) one lift point shall be sufficient.

e) For diameters smaller than or equal to 450 mm, manual labour can be used.

f) Loading boom or fork lift should not be used directly on or inside pipe.

A-3 PIPE STORAGE AT SITE

A-3.1 Stockpiling shall be done temporarily on a flat clear area as per Fig. 9.

A-3.2 For avoiding collapse of stacks use wooden posts or blocks.

A-3.3 Stacking shall not be higher than 2.5 m.

A-3.4 While stacking, alternate the socket/coupler ends at each row of stacked pipes as per Fig. 10.

A-4 CONSTRUCTION METHODS

A-4.1 Trench Preparation

A-4.1.1 *Dimensions*

The width of a sewer trench depends on the soil condition, type of side protection and the working space required at the bottom of trench for smooth installations. Increase in width over required minimum would unduly increase the load on pipe and cost of road restoration. Considering all above factors, the minimum trench width is specified as per Table 21.

A-4.1.2 *Excavation*

Excavation of sewer trenches shall be in straight lines as much as possible and to the correct depths and gradients as specified in drawings. However, because of inherent flexible property, these pipes can also be laid at very wide and smooth curvatures without transitional manholes. Instead of conventional manholes, the specified fittings such as tees and bends, etc, can be used at transitions.

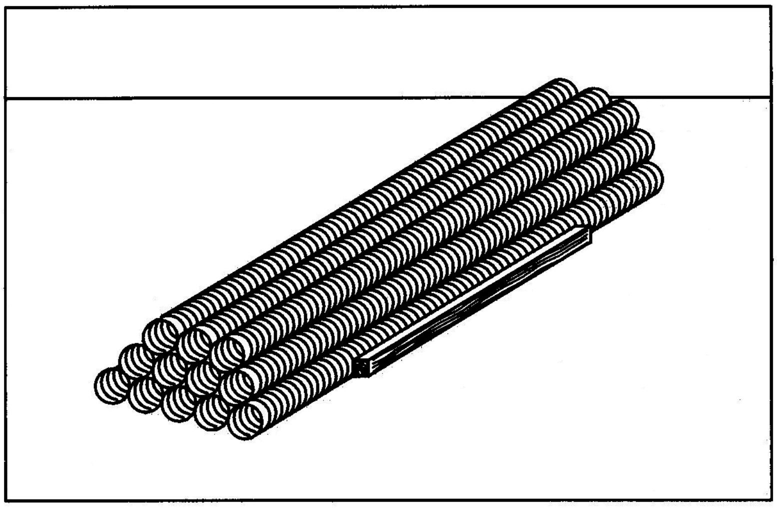


FIG. 9 STOCKING OF PIPES

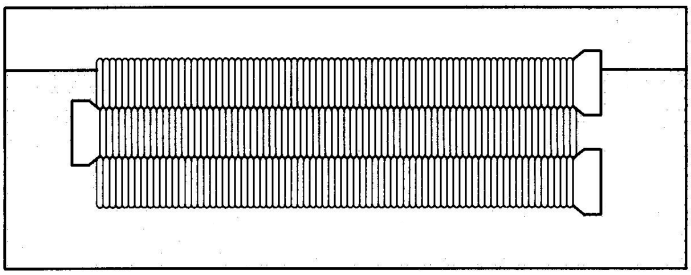


FIG. 10 STACKING OF SOCKET AND COUPLER ENDS

Table 21 Minimum Trench Widths
(*Clause* A-4.1.1)

All dimensions in millimetres.

Sl No. (1)	Pipe Diameter (2)	Trench Width (3)
i)	75 to 200	0.6
ii)	250	0.7
iii)	300	0.8
iv)	400	0.9
v)	600	1.2
vi)	800	1.3
vii)	900	1.6
viii)	1 000	1.8
ix)	1 200	2.0

Excavated spoils shall not be deposited in the near proximity to prevent the collapse of side of the trenches. The sides of the trench shall, however, be supported by shoring (where necessary) to ensure proper and speedy excavations and concurrently ensuring necessary protections to contiguous structures.

In the event, the presence of ground water is likely to cause instability in soil conditions, a well point system may be adopted for lowering of ground water table below the requisite trench bed level. If excavation is made deeper than necessary the same shall be filled and compacted.

A-4.1.2.1 *Shoring/mild steel sheet piling*

The protective shoring works shall be strong enough to prevent caving in of trench walls or subsidence of contagious areas adjacent to trench.

For wider and deeper trenches, a system of wall plates (wales) and struts of heavy timber section is commonly used as per the requisite structural design.

In non-cohesive soils with high ground water table, continuous interlocking mild steel sheet piling may be necessary to prevent excessive soil movements due to ground water percolation. Such sheet piling shall extend 1.5 m below the trench bottom unless the lower soil strata are adequately cohesive.

A-4.1.2.2 *Underground services*

The underground public and private utility services exposed due to the excavation shall be effectively supported under the guidance of the owners of such services.

A- 4.1.2.3 *Dewatering*

Sewer installation trenches shall be adequately dewatered for the placement of pipe at proper gradient till the pipe is integrated through socket and spigot joint/coupler assembly with the already laid segment. Precautions are to be taken to arrest floating of installed sewer segments against buoyant forces in case of sudden accumulation of water in the trench. The diameter wise minimum cover necessary to counteract the buoyant forces is given in Table 22.

For exceptional cases of higher level of ground water, additional anchoring at equal intervals would be necessary.

Table 22 Required Minimum Cover to Prevent Floatation

Sl No. (1)	Nominal Diameter mm (2)	Minimum Cover mm (3)
i)	75	65
ii)	100	77
iii)	150	102
iv)	200	127
v)	250	178
vi)	300	368
vii)	400	505
viii)	600	711
ix)	900	1 067
x)	1 050	1 219
xi)	1 200	1 372

NOTE — Computation is based on the pipes being completely empty, water table at the ground surface, solid density of 2 083 kg/m^3 and a soil friction angle appropriate for most sand/gravel mixtures. The average of the inside and outside diameters was used to determine solid and water displacement.

A-4.1.2.4 *Bedding*

a) Normally, even for the maximum combined loading (wheel load + backfill), any form of cement concrete structural bedding would not be necessary.
b) For maintenance of sewer slopes the initial backfill envelop with sand or gravel (as computed through structural design of buried flexible conduit) over a single BFS would be sufficient.
c) In the event, anchorage becomes imperative the transverse concrete anchorage blocks spaced at suitable interval shall also act as chairs for defining and maintaining the sewer slopes.

A-4.1.2.5 *Parallel pipe installation*

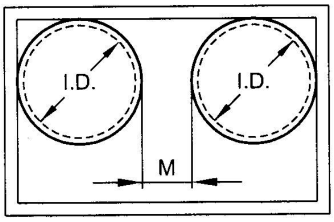
For cross drainage under roads, often parallel pipe installations become necessary. In such cases allowance for adequate spaces between pipes are imperative. The proposed configuration of such system is depicted in Fig. 11.

A-4.2 Laying and Jointing

A-4.2.1 *Laying*

A-4.2.1.1 *For shallow trenches*

Place the pipe manually on the initial backfill envelop directly.



Up to 600 mm I.D. : M = 300 mm

More Than 600 mm I.D. : $M = \frac{1}{2}$ I.D. of Larger Diameter Pipe

FIG. 11 INSTALLATION OF PARALLEL PIPES

A-4.2.1.2 *Deep trenches with shoring/mild steel sheet piling*

a) Make the trench reasonably free from ground water and other liquids.
b) Place the pipe on the top level cross-struts of the timber shoring/mild steel sheet piling frame work.
c) Dismantle one/two cross struts and lower the pipe to the immediate lower layer of the cross-struts and re-fix the struts immediately.
d) In the same manner, reach up to the initial back filling and place the pipe at proper slope.
e) Ensure anchorage, if any, after laying.

A-4.2.2 *Jointing*

Various methods for jointing such as regular coupler made by online process, spigot and sockets are used.

The moulded socket will have a suitable internal surface with profiles ribs for insertion of the next pipe into it. The socket end of the pipe to be inserted will have corrugated outer layer. On first valley segment of corrugated pipe (destined to be pushed into the coupler) one elastomeric rubber ring needs to be placed which is pushed into the coupler socket. This provides sufficient gripping lock and leak proof joint.

Similar system is also used for fabricated accessories or moulded fittings required such as tee, bends, elbows, reducer end caps for the purpose of installation of the system related to drainage/sewerage.

For quality connections following steps are to be ensured, failing which the performance aspects are to be severely compromised:

a) The non-coupler end needs to be thoroughly cleared and shall be free from any foreign material.
b) Use a clean rag or brush to lubricate the non-coupler end with lubricant.
c) Clean and lubricate the coupler end of the pipe to be laid in similar manner.
d) Lubricate the exposed gasket in the same manner with pipe lubricant.
e) Keep the lubricated non-coupler end free from dirt, backfill material, and foreign matter so that the joint integrity is not compromised.
f) Push the coupler into non-coupler and align properly. Always push coupler end into non-coupler end.

For smaller diameter pipes simple manual insertion shall be sufficient. In every methodology, it should be ensured that the coupler end is adequately 'homed' within non-coupler end to ensure installation and tight joining seal. Therefore, prior to insertion always place a homing mark on appropriate corrugation of the non-coupler end.

A-4.2.2.1 *Jointing different pipe types or sizes*

Sewerage/drainage system often encounters connecting pipes of different materials/sizes, etc. The fittings or adapters specifically designed for the purpose are available.

A selection of fittings designed to make the transition from one material directly to another are also available. In few cases, fitting may need to be used in combination with separate manufacturer's gasket or coupler to give proper effect to the transition.

A-4.2.3 *Manholes and Catch Pit Connections*

Brick masonry manholes can also be used at changes in pipe material, size, grade, direction and elevation. Manufacturer specified pre-fabricated appurtenant structures made of thermoplastic materials shall also be available for onsite user friendly installations. Similar methodology shall be followed for integration of catch pits.

A-4.2.4 *Sewer Connections*

Other connecting lines shall be integrated with the already laid system in the same manner as of original sewer lines.

A-4.2.5 *Construction of Backfill Envelope and Backfilling of the Trenches*

These pipes and well compacted backfill envelope work together to support soil and traffic load.

In general, material used for construction of backfill envelop around the pipe comprises the following:

a) Initial backfill;
b) Side fill; and
c) Top backfill.

The material for backfill envelop shall be as per the structural design of flexible buried conduit. It can be the same material that were removed in the course of excavation or it can be fine sand/course sand/gravel depending on the over burden and superimposed load, but it should be the concrete which invariably induces undesired rigidity in the system.

The remaining portion of backfilling shall be the materials that were removed in the course of excavation. These materials shall consist of clean earth and shall be free from large clod or stone above 75 mm, ashes, refuse and other injurious materials.

After completion of laying of pipes, etc, first the backfill envelope shall be constructed as per design around pipe. Voids must be eliminated by knifing under and around pipe or by some other technique and compacted with necessary watering, either by hand rammers or compactors to a possible maximum level of proctor density.

Backfilling shall start only after ensuring the water tightness test of joints for the concerned sewer segments. However, partial filling may be done keeping the joints open.

Precautions shall be taken against floatation as per the specified methodology and the minimum required cover.

ANNEX B

(*Foreword*)

STRUCTURAL DESIGN

B-1 GENERAL

In general, structural design of a thermoplastics pipeline construction by applying analytical or numerical methods is not needed. Whether any calculated prediction of the pipe behaviour holds true in reality is strongly dependent on whether the installation conditions used for the calculation are the same as those used for the installation. Therefore, it is important that efforts be put into controlling the input values by extensive soil surveys and monitoring of the installation. In many cases, practical and/or reference information, such as listed in Table 23 is available and results in good prediction of the pipe performance.

B-2 STRUCTURAL DESIGN BASED ON A DESIGN GRAPH

Designers first need to establish permitted deflections, average and maximum. An intensive study of the deflection history of pipes installed globally under different conditions for a period of 25 years has resulted in experience as presented in the design graph shown in Fig. 12. For the deflection mentioned in the design graph, the strain will be far below the design limit and therefore need not be taken into account in the design.

The graph is valid under the conditions given in Table 24.

B-3 STRUCTURAL DESIGN BASED ON CALCULATIONS

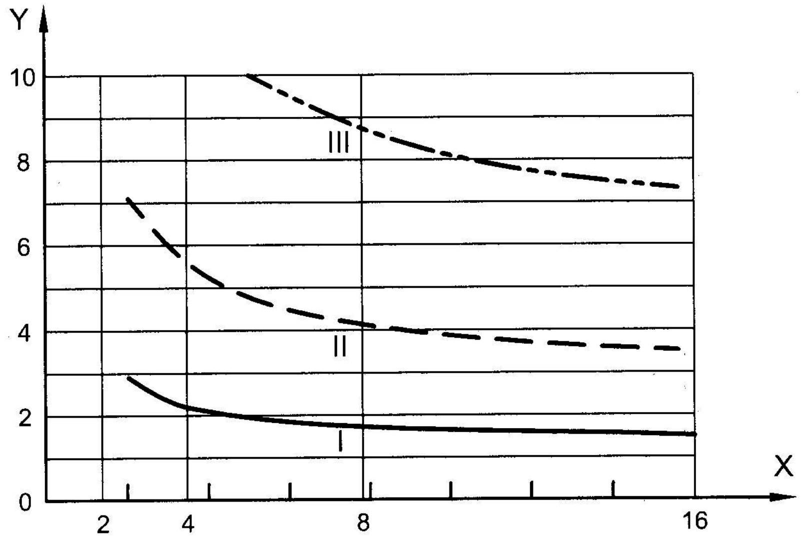
When structural design is required, such as in cases where no other information exists, then a method as per established practices may be used. If input values for the pipes are required, the values given in Table 23 are recommended.

It is recommended that, for reasons of serviceability, the calculated average deflection values do not exceed the values given in Table 25.

Table 23 Physical Characteristics of Thermoplastic Pipe Materials

(*Clauses* B-1 *and* B-3)

Sl No. (1)	Characteristics (2)	PP (3)	PE (4)
i)	Flexural modulus, $E_{(1\ Min)}$, in MPa	1 250-1 900	1 000-1 200
ii)	Density, in kg. m^{-3}	900	950
iii)	Co-efficient of linear thermal expansion, in mm.mm^{-1}.K^{-1}	14×10^{-5}	17×10^{-5}
iv)	Thermal conductivity, in W.K^{-1}.m^{-1}	0.2	0.4-0.5
v)	Poisson's ratio	0.4	0.4
vi)	Specific heat, in J.kg^{-1}.K^{-1}	—	2 300-2 900



Key

X — ring stiffness, in kN/m²
Y — pipe deflection, in percent
I — "well" compaction
II — "moderate" compaction
III — "non-" compaction (not recommended)

FIG. 12 DESIGN GRAPH (LONG TERM PIPE DEFLECTION)

Table 24 Validity of the Design Graph

(*Clause* B-2)

Sl No. (1)	Design Consideration (2)	Conditions (3)
i)	Pipe system	Conforming to requirements of this standard.
ii)	Installation depth	0.8 to 6.0 m
iii)	Traffic loading	Included
iv)	Installation quality—Installation catagories, well compaction, moderate compaction and non-compaction should reflect the workmanship on which the designer can rely	a) Well compaction (I): The embedment soil of a granular type is placed carefully in the haunching zone and compacted, after which the soil is placed in shifts of maximum 300 mm, after which each layer is compacted carefully. The pipe shall at least be covered by a layer 150 mm. The trench is further filled with soil of any type and compacted. Typical values for the proctor density are above 94 percent. b) Moderate compaction (II): The embedment soil of a granular type is placed in shifts of maximum 500 mm after which each layer is compacted carefully. The pipe shall at least be covered by a layer of 150 mm. The trench is further filled with soil of any type and compacted. Typical values for the proctor density are in the range of 87 percent to 94 percent. Sheeting/sheet piling given below the spring line of sewer in accordance with the recommendations in Manual on sewerage and Sewage Treatment, CPHEEO, MoUD, Govt of India, if removed after compaction one should realise that the 'well compaction' or 'moderate compaction' level will be reduced to the 'non-compaction' (III) level.

B-4 SELECTION OF STIFFNESS CLASS OF FITTINGS

It is recommended that the minimum stiffness class of fittings to be used should be same as that of the structured wall thermoplastic pipe.

Table 25 Recommended Design Deflection Limits

(*Clause* B-3)

Sl No. (1)	Stiffness Class SN (2)	Average Initial Deflection Percent (3)	Average Long Term Deflection Percent (4)
i)	SN 2	5	8
ii)	SN 4, 8, 16	8	10

ANNEX C

(*Tables* 1 *and* 3)

DETERMINATION OF OXIDATION INDUCTION TIME

C-1 This Annex specifies for measuring the oxidation induction time in oxygen at a specified temperature of polyolefin materials for or from pipes or fittings.

It may be used for assessing the thermal stability of either raw materials or finished products.

C-1.1 Oxidation Induction Time (Isothermal OIT)

Relative measure of a stabilized material's resistance to oxidative decomposition, determined by the calorimetric measurement of the time interval to the onset of exothermic oxidation of the material at a specified temperature in an oxygen or air atmosphere, under atmospheric pressure.

NOTE — It is expressed in minutes (min).

C-1.2 Oxidation Induction Temperature (Dynamic OIT)

Relative measure of a stabilized material's resistance to oxidative decomposition, determined by the calorimetric measurement of the temperature of the onset of exothermic oxidation of the material when subjected to a specified heating rate in an oxygen or air atmosphere, under atmospheric pressure.

NOTE — It is expressed in degrees Celsius (ºC).

C-2 PRINCIPLE

C-2.1 General

The time for which, or the temperature up to which, an antioxidant stabilizer system present in a test specimen inhibits oxidation is measured while the specimen is held isothermally at a specified temperature or heated at a constant rate in an oxygen or air atmosphere. The oxidation induction time or temperature is an assessment of the level (or degree) of stabilization of the material tested. Higher test temperatures will result in shorter oxidation induction times; faster heating rates will result in higher oxidation induction temperatures. The oxidation induction time and temperature are also dependent on the surface area of the specimen available for oxidation. It should be noted that tests carried out in pure oxygen will result in a lower oxidation induction time or temperature than tests performed under normal atmospheric-air conditions.

NOTE — The oxidation induction time or temperature can be indicative of the effective antioxidant level present in the test specimen. Caution should be exercized in data interpretation, however, since oxidation reaction kinetics are a function of temperature and the inherent properties of the additives contained in the sample. For example, oxidation induction time or temperature results are often used to select optimum resin formulations. Volatile antioxidants or differences in activation energies of oxidation reactions may generate poor oxidation induction time or temperature results, even though the antioxidants may perform adequately at the intended temperature of use of the finished product.

C-2.2 Oxidation Induction Time (Isothermal OIT)

The specimen and a reference material are heated at a constant rate in an inert gaseous environment (a flow of nitrogen). When the specified temperature has been reached, the atmosphere is changed to oxygen or air maintained at the same flow rate. The specimen is then held at constant temperature until the oxidative reaction is displayed on the thermal curve. The isothermal OIT is the time interval between the initiation of oxygen or air flow and the onset of the oxidative reaction. The onset of oxidation is indicated by an abrupt increase in the specimen's evolved heat and may be observed by a differential scanning calorimeter (DSC). The isothermal OIT is determined in accordance with **C-7.6.1**.

C-2.3 Oxidation Induction Temperature (Dynamic OIT)

The specimen and a reference material are heated at a constant rate in oxygen or air atmosphere until the oxidative reaction is displayed on the thermal curve. The dynamic OIT is the temperature of the onset of the oxidative reaction. The onset of oxidation is indicated by an abrupt increase in the specimen's evolved heat and may be observed by a differential scanning calorimeter (DSC). The dynamic OIT is determined in accordance with **C-7.6.2**.

C-3 APPARATUS AND MATERIALS

C-3.1 General

Clause **C-3.5** to **C-3.8** shall be followed as applicable (**C-3.7** and **C-3.8** are required only for oxidation induction time measurements).

C-3.2 DSC Instrument — The DSC instrument shall be able to achieve a maximum temperature of at least 500°C. For oxidation induction time measurements, it shall be capable of maintaining an isothermal stability of ± 0.3°C at the test temperature over the duration of the test, typically 60 min.

For high-precision measurements, an isothermal stability of ± 0.1°C is recommended.

C-3.3 Crucibles — Specimens shall be placed in open or closed ventilated crucible that allows unperturbed contact with the surrounding atmosphere. Preferably, crucibles should be made of aluminum. Crucibles made of different materials may be used by agreement between the interested parties.

NOTE — The composition of the crucible material can influence the oxidation induction time temperature test result significantly (that is, including any associated catalytic effects). The type of containment system used depends on the intended application of the material being tested. Polyolefins used in the wire and cable industry typically require copper or aluminum crucibles whereas, for polyolefins used in geomembrane and vapour-barrier film applications, only aluminum crucibles are used.

C-3.4 Flowmeter — For gas flow calibration, a flow rate measuring device such as a rotameter or soap-film flowmeter shall be used together with a flow adjusting value. Mass flow controlling devices shall be calibrated against a positive displacement device.

C-3.5 Oxygen — The oxygen used shall be of 99.55 percent ultra high purity grade (extra dry) or better.

WARNING — The use of pressurized gas require safe and proper handling. Furthermore, oxygen is a strong oxidizer that accelerates combustion vigorously. Keep oil and grease away from equipment using or containing oxygen**.**

C-3.6 Air — The pressurized air used shall be dry and free of oil and grease.

C-3.7 Nitrogen — The nitrogen used shall be of 99.99 percent ultra high purity grade (extra dry) or better.

C-3.8 Gas-Selector Switch and Regulators — The DSC apparatus used for oxidation induction time measurements needs to be switched between nitrogen and oxygen or air. The distance between the gas switching point and the instrument cell should preferably be kept as short as possible, with a dead time of less than 1 min, to minimize the switching volume. Accordingly, for a flow rate of 50 ml/min, the dead volume would have to be less than 50 ml.

NOTE — Increased precision can be obtained, if the dead time is known. One possible means of determining dead time is to carry out a test using a non-stabilized material which will oxidize immediately in the presence of oxygen. The induction time from the test will provide a correction for subsequent OIT determination.

C-4 TEST SPECIMENS

C-4.1 General

Specimens shall have a constant thickness of 650 ± 100 µm and parallel surfaces shall be flat and shall not show any burrs or scars.

NOTE — Depending on the material and its process history, dimensions and service conditions, the methods of samples and specimen preparation may be crucial to the consistency of the results and their significance. In addition, the surface to volume ratio of the test specimen, poor specimen uniformity, residual stresses or lack of contact between specimen and crucible can affect test precision adversely.

If measurements of the OIT profile across the specimen thickness are required, specimens of significantly lower thickness than 650 µm may need to be used. This shall be noted in the test report.

C-4.2 Specimens from Compression-Moulded Plates

Following IS 13360 (Part 2/Sec 1), the test sample shall be compression-moulded into sheet of thickness complying with **A-4.1** to yield consistent specimen morphology and thickness. Alternatively, a specimen of suitable thickness can be cut from a thicker compression-moulded plate. Unless otherwise specified, heating at the moulding temperature shall be limited to 5 min. Preferably, a borehole cutter should be used to punch out from the plate a disc of diameter just less than the inner diameter of the sample crucible. Specimen discs shall be small enough to lay flat in the crucible and shall not be stacked to increase mass.

NOTE — Specimen mass will vary depending on disc/diameter. For a typical diameter of 5.5 mm, specimen discs cut from sheet will have a mass of approximately 12 mg to 17 mg, depending on the density of the material.

C-4.3 Specimen from Injection-Moulded Plates or Melt Flow Extrudates

Specimens may also be obtained from injection-moulded samples of thickness complying with **C-4.1**, for example prepared in accordance with IS 13360 (Part 2/Sec 3). Preferably, a bore-hole cutter should be used to punch out a disc of diameter just less than the inner diameter of the sample crucible.

Specimen can also be cut from melt flow indexer extrudates. In this case, the specimen shall be cut perpendicular to the extrudate length. A visual inspection of the specimen shall be performed to ensure that it is free of voids. Preferably, a microtome should be used to cut specimens to a constant thickness of 650 ± 100 µm.

C-4.4 Specimen from Finished Parts

Examples of such parts are pipes and fittings. Disc-shaped pieces shall be cut from the finished part in accordance with the referring standard so as to obtain specimens of thickness 650 ± 100 µm.

The following procedure is recommended to prepare specimens from thick walled finished part, obtain a cross-section of the wall by using a core drill directed racially through the wall, where the diameter of the core is less than the inner diameter of the sample crucible. Take care not to over heat the specimen during the cutting operation. Cut discs of specified thickness

from the core, preferably by using a microtome. If surface effects are of prime interest, cut discs from the inner and outer surfaces and test them with the original surface facing upward. If the characteristics of the base material are desired, cut a middle-section disc by removing the outer and inner surfaces.

NOTE — Specimen mass will vary depending on disc/diameter. For a typical diameter of 5.5 mm, specimen discs cut from pipes or fittings will have a mass of approximately 12 mg to 17 mg, depending on the density of the material.

C-5 TEST CONDITIONS AND SPECIMEN CONDITIONING

A short length completed duct (approximately 300 mm) placed in an oven at temperature of 68 ± 1°C for 8 h. The sample shall then be allowed to cool at room temperatures for at least 16 h. The sample shall be clean and dry. The sample shall then be tested**.**

C-6 CALIBRATION

C-6.1 Oxidation Induction Time (Isothermal OIT)

A modified two-point calibration procedure shall be used. Indium and tin can be used as calibration materials for polyoefins since their respective melting points encompass the specified analysis temperature range of 180°C to 230°C. If other plastics are investigated, other calibration materials may need to be used. Calibration shall be performed under nitrogen using closed crucibles.

Ensure that the oven is properly clean, for example by heating up in a nitrogen atmosphere at a temperature of approximately 500°C to 550°C for at least 10 min followed after cooling by a cleaning with a cloth, if necessary.

Establish an oxygen flow of 50 ml/min ± 10 percent through the apparatus at a temperature of at least 10°C below the expected melting point of one of the calibration metals, for example indium or tin.

Heat the calibration metal in a sealed aluminum pan at a rate of 1°C/min until the melting endotherm is recorded, using an empty sealed aluminum pan as reference. If the apparatus does not automatically do so, mark the indicated temperature on a chart at intervals in the region of the endotherm so that the melting point can be determined with a precision of ± 0.1°C.

Take the melting point of the metal to be the temperature given by the intercept of the extended baseline and the extended tangent to the first slope of the endotherm. Repeat the procedure given in using a piece of the other calibration.

Adjust the apparatus so that the indicated melting point of indium lies within 156.6 ± 0.3°C and that of tin lies within 231.9 ± 0.3°C.

The following melting profiles shall be used if the calibration procedure does not provide heating rate correction:

a) Indium : ambient to 145°C at 10°C/min, 145°C to 165°C at 1°C/min
b) Tin : ambient to 220°C at 10°C/min, 220°C to 240°C at 1°C/min

C-6.2 Oxidation Induction Temperature (Dynamic OIT)

The instrument shall be calibrated in accordance with the procedure described in **C-7.1**, using nitrogen or air as purge gas.

C-7 PROCEDURE

C-7.1 Setting Up the Instrument

Switch the instrument on at least 1 h prior to any calibration or testing to allow it to reach steady state conditions.

C-7.2 Loading the Test Specimen into the Crucible

If the specimen is cut from the inner or outer surface of a pipe or fitting, it shall be placed in the crucible with the surface of interest facing upward. The test specimen shall be weighed to the nearest ± 0.5 mg as heat flow is not the main point of interest in this case. The specimen disc is placed into the appropriate crucible type. If a cover is necessary, it shall be priced to permit flow of oxygen or air to the specimen. Crucibles shall not be sealed unless they are ventilated.

C-7.3 Insertion of Crucible

Loading of the specimen and reference crucibles should preferably be carried out at, or slightly above room temperature (maximum 50°C) to prevent condensation of moisture on or inside of crucibles. Unless crucibles are loaded by an automatic specimen changer, use tweezers or other suitable tools to insert the crucibles in the crucible holder, checking that there is good thermal contact between the crucible and the crucible holder. Do not use bare hands. After loading the crucibles close the cover of the crucible holder if it has one.

C-7.4 Nitrogen, Air and Oxygen Flow

The nitrogen or air purge gas flow used for measurements and calibration shall be the same. Any change in flow rate requires recalibration. A typical purge gas flow rate is 50 ± 5 ml/min.

The flow rate of oxidizing gas shall be the same as the used for nitrogen.

C-7.5 Sensitivity Adjustment

The instrument sensitivity shall be adjusted so that the difference in vertical height on the stopped change curve becomes 50 percent or more of the full scale of the recording device. Computer-controlled instruments do not need this adjustment.

C-7.6 Performance of Measurement

C-7.6.1 *Oxidation Induction Time (Isothermal OIT)*

Load specimen and reference crucibles at ambient temperature. Pre-purge the instrument with nitrogen for 5 min prior to beginning the heating cycle.

Programmed heating of the specimen under nitrogen flow shall be started from ambient temperature and continued to the test temperature at a rate of 20°C/min. Preferably, isothermal test temperatures shall be chosen to full 10°C values and changed only in steps of full 10°C. Other test temperatures may be used as per agreement between the interested parties. Particularly, specimen yielding oxidation induction times of less than 10 min should be released at a lower temperature. Specimens yielding oxidation induction times of greater than 60 min should be retested at a higher temperature.

When the set temperature has been reached, programmed heating shall be discontinued and the specimen shall be equilibrated for 3 min at the set temperature.

The recorder shall be turned on.

Once the equilibrium time has expired the gas shall be changed to oxygen or air at a flow rate identical to the rate used for nitrogen. The changeover point to oxygen air flow shall be marked as the zero time of the test.

The isothermal operation shall be continued until at least 2 min have elapsed after the steepest point of the exotherm has been displayed (*see* Fig. 13). Alternatively, the test may be terminated, if time requirements specified or agreed between the interested parties have been met.

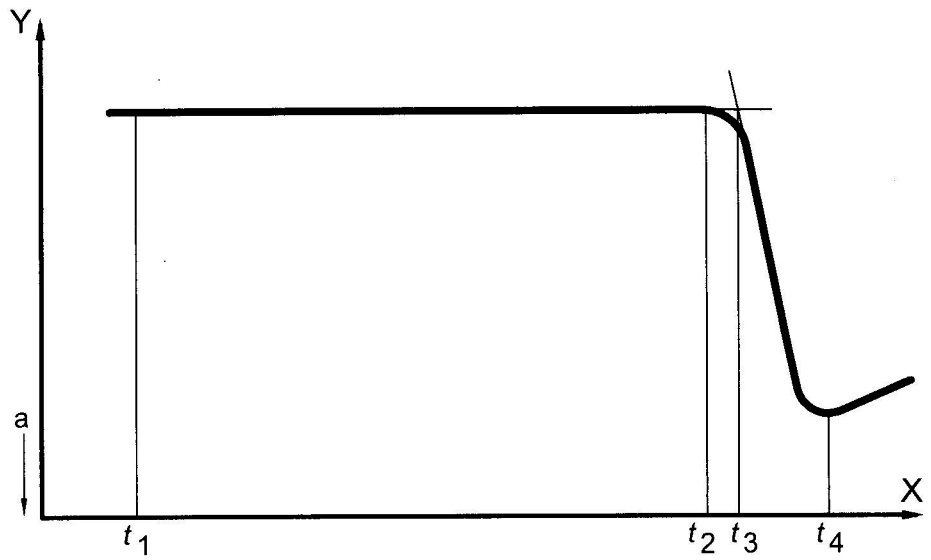
Upon completion of the test, the gas selector should be switched back to nitrogen and the instrument cooled down to ambient temperature. If additional testing is being conducted, cooling the instrument cell below 60°C should be sufficient.

The number of tests to be carried out on each sample shall be established by agreement between the interested parties. Preferably, specimens should be tested in duplicate, and the arithmetic means as well as the lower and upper values reported.

NOTE — Oxidative induction time is a complex function of temperature and the additives in the polymer. Therefore, extrapolation or comparison of date obtained at different temperatures is not valid unless justified by experimental results.

C-7.6.2 *Oxidation Induction Temperature (Dynamic OIT)*

The instrument shall be pre-purged with the purge gas to be used for measuring, that is oxygen or air, for 5 min with the specimen and reference crucibles loaded



a — exothermic
Y — heat flow rate
t_2 — onset of oxidation
t_4 — time to oxidation peak
X — time
t_1 — changeover to oxygen or air (time zero)
t_3 — intercept point determined by tangent method (oxidation induction time)

FIG. 13 SCHEMATIC OXIDATION INDUCTION TIME CURVE — TANGENT METHOD OF ANALYSIS

at ambient temperature prior to beginning the heating cycle.

Programmed heating of the specimen under oxygen or air flow shall be started at ambient temperature and continued to a temperature at least 30°C above the steepest point on the exotherm (*see* Fig. 14). Preferred heating rates are 10°C/min and 20°C/min. alternatively, the test may be terminated, if temperature requirements stated in the product specification or as agreed between the interested parties have been met.

Upon completion of the test, the instrument should be cooled down to ambient temperature. If additional testing is being conducted cooling the instrument cell below 60°C should be sufficient.

The number of tests to be carried out on each sample shall be established by agreement between the interested parties. Preferably, specimens should be tested in duplicate, and the arithmetic mean as well as the lower and upper values reported.

C-8 EXPRESSION OF RESULTS

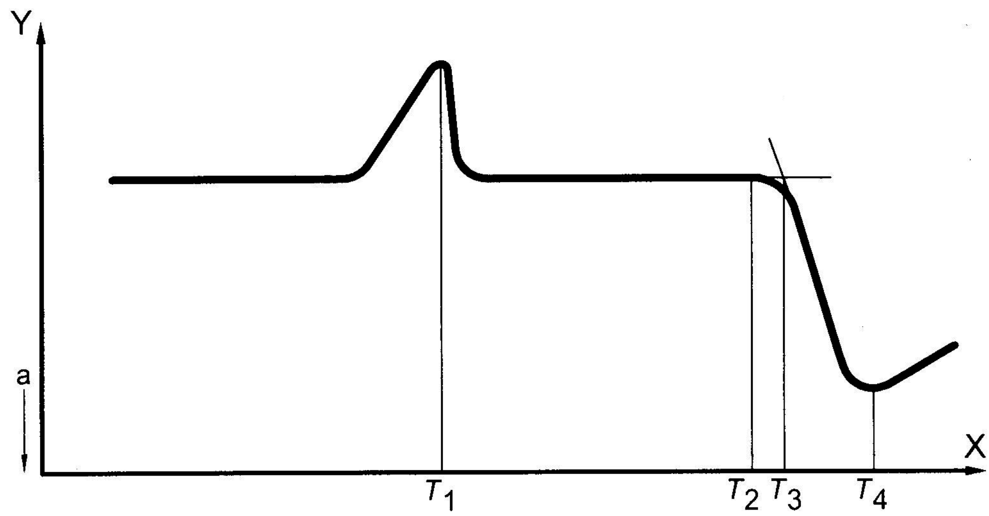
The data shall be plotted with the heat flow rate on the y-axis and time or temperature, as applicable, on the x-axis. In the case of manual evaluation the x-axis should be expanded as much as possible to facilitate analysis.

The recorded baseline shall be extended well beyond the onset of the oxidative reaction exortherm. The steepest linear slope of this exotherm shall be extrapolated to intercept the extended baseline (*see* Fig. 13 or 14). The intercept point representing the oxidation induction time or temperature shall be measured to a resolution of three significant figures.

The tangent method described above is the preferred means of determining the intercept point, but the selection of the appropriate tangent to the exotherm may be difficult, if the exothermic peak has a leading edge. Exothermic peaks with leading edges may occur, if the oxidation reaction is slow. If the selection of the appropriate slope to be used for the tangent method is not obvious, an offset method may be used. A second baseline shall be drawn parallel to the first baseline at a threshold distance of 0.05 W/g (*see* Fig. 15 or 16) from the first baseline (*see* next paragraph). The intersection of this second line with the exotherm signal is defined as the onset of oxidation.

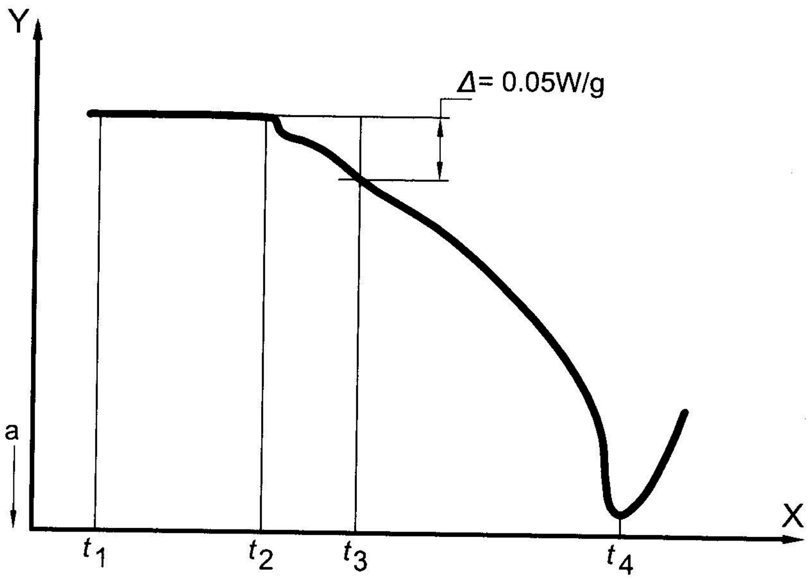
Thermograms having leading edges can also be due to poor specimen preparation, that is specimens being of varying thickness, not being flat or having burrs or scars. Thus, before applying the threshold method described for evaluation of results, it is recommended that the scan be repeated, making sure that all specimen requirements described in **C-5** are properly met, to confirm the leading edge shape of the thermogram.

Other procedures or other values for the threshold distance from the baseline may be used by agreement between the interested parties.



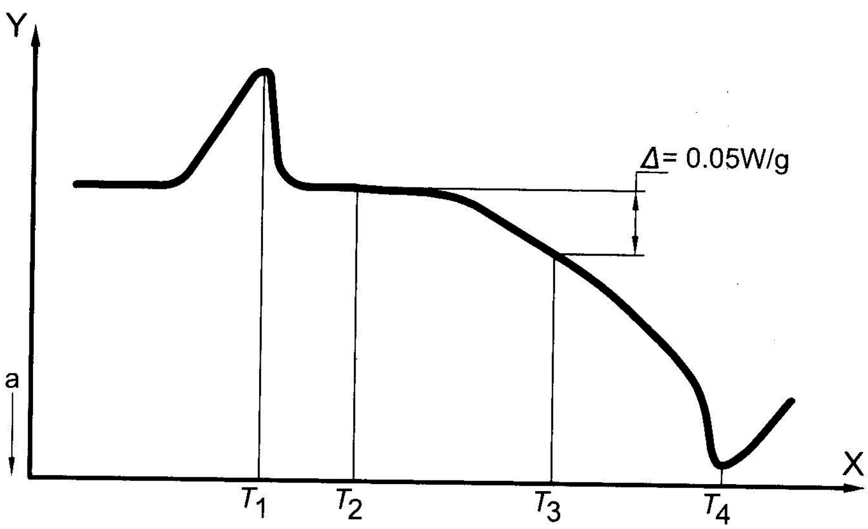
a — exothermic
Y — heat Flow Rate
T_2 — onset of oxidation
T_4 — temperature of oxidation peak
X — temperature
T_1 — melting temperature of polymer
T_3 — intercept point determined by tangent method (Oxidation induction tempture)

FIG. 14 SCHEMATIC OXIDATION INDUCTION TEMPERATURE CURVE — TANGENT METHOD OF ANALYSIS



a	—	exothermic	X	—	time
Y	—	heat flow rate	t_1	—	changeover to oxygen or air (time zero)
t_2	—	onset of oxidation	t_3	—	intercept point determined by offset method (Oxidation induction time)
t_4	—	time of oxidation peak			

FIG. 15 OXIDATION INDUCTION TIME CURVE WITH LEADING EDGE — OFFSET ANALYSIS METHOD



a	—	exothermic	X	—	temperature
Y	—	heat flow rate	T_1	—	melting temperature of polymer
T_2	—	onset of oxidation	T_3	—	intercept point determined by offset method (Oxidation induction temperature)
T_4	—	temperature of oxidation peak			

FIG. 16 OXIDATION INDUCTION TEMPERATURE CURVE WITH LEADING EDGE — OFFSET ANALYSIS METHOD

ANNEX D

(*Tables* 8 *and* 9)

METHODS FOR VISUALLY ASSESSING THE EFFECTS OF HEATING

D-1 This Annex specifies two methods for assessing the effects of heating on injection — moulded thermoplastics pipe fittings — Method A, using an air oven, and method B, using a liquid bath. In case of disagreement, Method A is the reference method.

This Annex is applicable to cement welded fittings as well as to flanged fittings and fittings incorporating elastomeric seals and to fittings consisting of the assembly of several moulded parts (for example union connectors). It is applicable to both pressure and non-pressure fittings.

D-2 PRINCIPLE

Complete mouldings are subjected to an elevated temperature in an air-circulating oven or a liquid bath for a given period of time, depending upon the wall thickness of the fitting and the material being moulded.

The surfaces of the moulding are examined before and after heating and any cracks, blisters, delaminations or opening of fusion lines are measured and expressed as a percentage of the wall thickness.

D-3 TEST PARAMETERS

The following test parameters as given below shall apply for the material used in manufacture of the fittings:

a) Test temperature, T (*see* **D-4.1.1** and **D-4.3**);
b) Number of test pieces (*see* **D-4.2.2**);
c) Heating time, t (*see* **D-4.3.3**);
d) Test method to be used and the test liquid (for Method B, only); and
e) The acceptable limits for the occurrence or dimensions of any cracks or other features found (*see* **D-4.3.6**).

Unless otherwise specified, the test parameters shall be in accordance with Table 26.

D-4 METHOD A

D-4.1 Apparatus

D-4.1.1 *Air-Circulating Oven, Thermostatically Controlled*, equipped with a thermostat so that the temperature of the working zone can be maintained at the prescribed test temperature throughout the test and of sufficient heating capacity to enable the test temperature to be regained within 15 min of insertion of the test pieces.

D-4.1.2 *Thermometer*, *G*raduated in 0.5°C or a type 'T' thermocouple with a resolution of 0.1°C and an accuracy of at least ± 0.8°C.

D-4.2 Test Pieces

D- 4.2.1 *Preparation*

After removing any runners, take the complete molding as test piece. If the fitting incorporates an elastomeric sealing ring, remove the ring before testing. In the case of fittings assembled from more than one element, separate the components and then test, out of contact with each other.

D-4.2.2 *Number*

At least three pieces shall be tested.

D-4.3 Procedure

D-4.3.1 Set the oven temperature (*see* **D-4.1.1**) at the test temperature of T ± 2°C in accordance with Table 26.

D-4.3.2 Put the test pieces in the oven and arrange them so that they are standing on one side of their sockets

Table 26 Test Parameters

(*Clauses* D-3, D-4.3.1, D-4.3.3 *and* D-5.3.3)

Sl No.	Material	Temperature, T °C	Heating Time	
			Mean Wall Thickness mm	Duration, t min
(1)	(2)	(3)	(4)	(5)
i)	PE	110 ± 2	$e_m \leq 3$	15
			$3 < e_m \leq 10$	30
ii)	PP	150 ± 2	$10 < e_m \leq 20$	60
			$20 < e_m \leq 30$	140
			$30 < e_m \leq 40$	220
			$40 < e_m$	240

wherever possible, avoiding contact with another test piece or the sides of the oven.

D-4.3.3 Leave the test pieces in the oven until the oven returns to the test temperature of $T \pm 2°C$ and for a further period, t, dependent on the mean wall thickness, e_m, of the thickest part of the test piece(s) in accordance with Table 26.

D-4.3.4 Remove the test pieces from the oven, taking care not to deform or damage them.

D-4.3.5 Cut the test pieces with a sharp knife or razor blade while they are still hot, to enable the dimensions of cracks, blisters, delaminations and weld line openings, if any, to be measured as required. Allow the test pieces and/or parts to cool in air until they can be handled without deformation.

The following number of cuts should be made:

a) For cylindrical components of $d_n \leq 160$ mm, not less than two cuts equally spaced around the periphery of the mouth of each socket or spigot of the component.

b) For cylindrical components of $d_n > 160$ mm, not less than four cuts equally spaced around the periphery of the mouth of each socket or spigot of the component.

NOTE — For d_n, *see* Fig. 17.

D-4.3.6 Examine each test piece for and record any surface changes, such as cracks, delaminations and weld-line openings as well as changes inside the wall, such as blisters and in the gating area. Determine the extent of such defects in the gating area as a percentage of the wall thickness as follows:

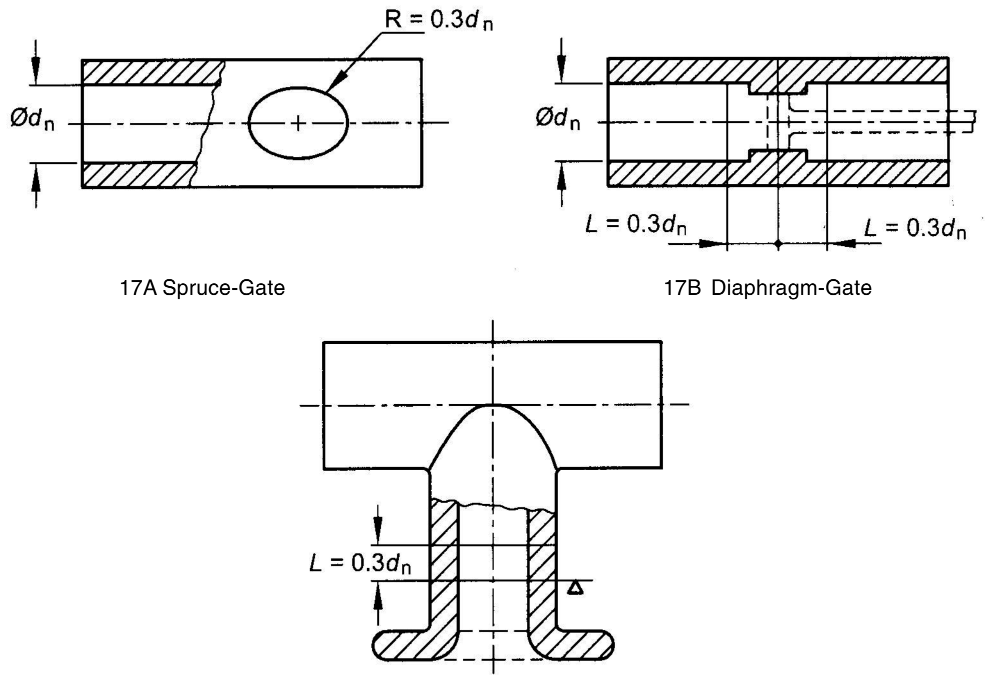
a) For spruce-gated mouldings (*see* Fig. 17) around the injection point(s) within a radius, $R = 0.3d_n$ with a maximum value of 50 mm.

b) For ring-or-diaphragm-gated mouldings (*see* Fig. 17) within a length, $L = 0.3d_n$ of the cylindrical portion of the gating area. In the case of cracks running through the whole wall thickness of the gating area, determine also the length of the crack.

c) For mouldings containing fusion lines, determine the widest and deepest part(s) of any open part of the fusion line.

d) For all other parts of the moulding beyond the gating area, examine the surface for any change such as cracks, blisters and delaminations of the wall.

e) For all other parts of the moulding beyond the gating area, examine the surface for any change such as cracks, blisters and delamination of the wall.



17A Spruce-Gate

17B Diaphragm-Gate

17C Ring-Gate

FIG. 17 INJECTION GATING AREAS

D-5 METHOD B

D-5.1 Apparatus

D-5.1.1 *Heating Bath*, shall be thermostatically controlled, at the prescribed test temperature of T ± 2°C. The volume and agitation of the bath shall be such that the temperature remains within the specified temperature range when the test pieces are immersed. The liquid chosen shall be stable at the specified temperature and shall not otherwise affect the test piece. It shall be ensured that the liquid does not cause any safety or health risks.

NOTES

1 Glycerin, glycol, mineral oil free fro aromatic hydrocarbons, or a solution of calcium chloride may be suitable, depending upon which of the materials covered by this method is under test. For example, all these liquids are suitable for PVC-U, but the use of glycols is not appropriate for ABS fittings, for which the selection of an appropriate mineral oil is preferable.

2 Attention is drawn to my relevant legislation which requires that the use of the liquid chosen do not cause any safety or health risks.

D-5.1.2 *Holder*, to support the test piece(s) within the heating bath. The fittings shall be supported in such a way as to not cause additional distortion.

D-5.1.3 *Thermometer*, graduated in 0.5°C or a type 'T' thermocouple with a resolution of 0.1°C and an accuracy of at least ± 0.8°C.

D-5.2 Test Pieces (*see* **D-4.2**)

D-5.3 Procedure

D-5.3.1 Set up the liquid bath (*see* **D-5.1.1**) to the prescribed test temperature of T ± 2°C.

D-5.3.2 Put the test pieces in the liquid bath and arrange them so that they are not touching each other or the side of the bath.

D-5.3.3 Leave the test pieces in the bath for a test period, t for the mean wall thickness, e_m of the thickest part of the test piece, in accordance with Table 26.

D-5.3.4 Remove the test pieces from the bath, taking care not to deform or damage them.

D-5.3.5 Cut the test pieces in accordance with **D-4.3.5**.

D-5.3.6 Examine the test pieces in accordance with **D-4.3.6**.

D-5.3.7 Record the composition of the liquid used in conjunction with the results obtained (*see also* **D-4.3.6**).

ANNEX E

(*Table* 11)

THERMOPLASTICS FITTINGS — TEST METHOD FOR MECHANICAL STRENGTH OR FLEXIBILITY OF FABRICATED FITTINGS

E-1 This Annex specifies a method for testing the mechanical strength or flexibility of fabricated thermoplastics fitting intended to be used in non-pressure applications.

E-2 PRINCIPLE

An assembly of a fabricated fitting and the relevant number of adjacent pipe(s) and anchorages (*see* Fig. 18 and Fig. 19) is subjected to a moment at the critical point. The critical point is where structural damage is most likely to start when increasing the moment. Either a specified moment, M, or a specified displacement, A, becomes the determining factor, whichever is reached first.

NOTE — It is assumed that the following test parameters are set:

a) Sampling procedure and the number of test pieces (*see* **E-4.2**);
b) Conditioning temperature, if other than 27 ± 5°C (*see* **E-5**);
c) Conditioning time, if other than 21 days (*see* **E-5**); and
d) If appropriate, the moment ($M = F \,.\, L$) or displacement to be applied (*see* **E-6**).

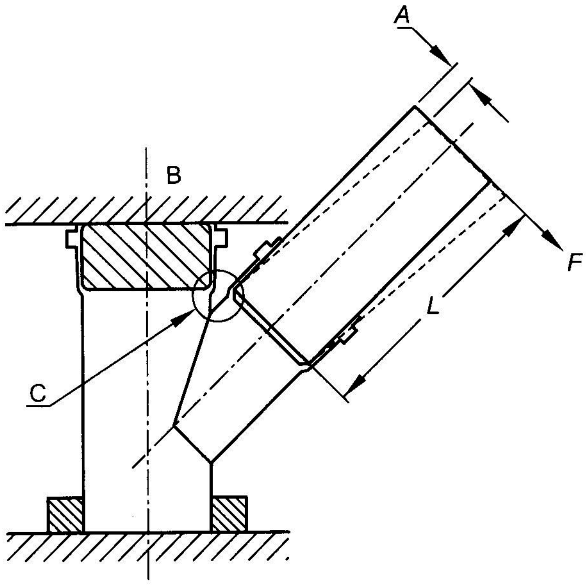
E-3 APPARATUS

E-3.1 Anchorage(s), capable of holding the body of the fabricated fitting rigid during the test. The anchorages shall not deform the fitting.

E-3.2 Equipment capable of applying a force that will result in moment in the critical point (*see* **E-6**). The direction of the force can be clockwise or anti-clockwise, provided that tensile stresses are applied to the critical point.

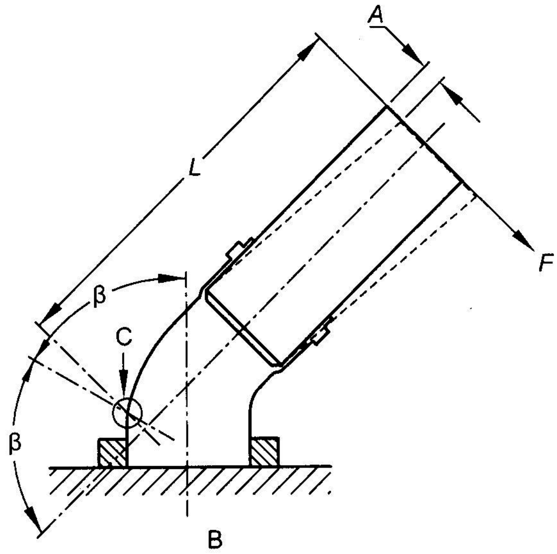
E-3.3 Equipment capable of determining the length, L of the arm to the critical point (*see* Fig. 18 and Fig. 19). When the displacement, A, is the determining factor, the arm, L, as shown in Fig. 18 and Fig. 19, shall be 1 200 ± 10 mm.

E-3.4 Force and/or displacement measurement instruments, capable of determining the force applied



A — discharge *B* — fixing
C — example of critical point

FIG. 18 TYPICAL TEST ASSEMBLY FOR A BRANCH WITH A SOCKET



A — discharge
B — fixing
C — example of critical point

FIG. 19 TYPICAL TEST ASSEMBLY FOR A BEND WITH A SOCKET

Table 27 Moment/Displacement to be Applied
(*Clauses* E-3.4 *and* E-6)

Sl No.	Nominal Size (DN/ID)	Minimum Moment kN.m	Minimum Displacement mm
(1)	(2)	(3)	(4)
i)	110	0.20	170
ii)	125	0.29	170
iii)	160	0.61	170
iv)	200	1.2	170
v)	250	2.3	170
vi)	315	3.1	170
vii)	355	3.5	170
viii)	400	4.0	170
ix)	450	4.5	170
x)	500	5.0	170
xi)	600	6.0	170
xii)	710	7.1	170
xiii)	800	8.0	170
xiv)	900	9.0	170
xv)	1000	10	170

NOTE — For DN/IDs up to and including 250, the value of the minimum moment approximate to the following equation:

$$M = 0.15 \times [DN]^3 \times 10^{-6} \text{ kN-m}$$

For DN/IDs greater than 250, the following equation is used:

$$M = 0.010 \times [DN] \text{ kN-m}$$

and/or the displacement of the end of the arm to which the force is applied, as applicable (*see* **E-4** and Table 27).

If a socket is designed to take up an angular deflection, β the total displacement shall be the sum of the displacement given by the design angles β as declared by the manufacturer, plus the specified displacement. In this case, however, a mechanical arrangement where the arm is fixed to the socket is preferred.

E-3.5 If necessary, additional means to ensure the tightness of the joint (*see* **E-4**).

E-4 TEST PIECE

E-4.1 Preparation

The test piece shall comprise of an assembly of the fabricated fitting, with a pipe of ring stiffness class for which the fitting is designed and fixing as appropriate.

In the case where a fitting is designed for both solid wall and structured-wall pipes, a solid wall pipe shall be used.

If the limiting factor is the moment, *M* the pipe may be replaced by a mechanical arrangement that ensures that the required moment is applied.

If the limiting factor is the displacement, *A* the pipe may be replaced by a mechanical arrangement of longitudinal rigidity not less than that of the specified pipe. In case of dispute the specified pipe shall be used.

Where a joint between a pipe and a fabricated fitting is made, the manufacturer's instructions shall be followed except that additional means may be used to ensure the tightness of the joint during the test.

E-5 CONDITIONING

Samples shall be stored at room temperature of 27 ± 2°C for at least 21 days before testing.

E-6 PROCEDURE

E-6.1 Non-mechanical jointed fabricated fittings (cemented or fused) carry out the following procedure at 27 ± 2°C. Assemble the fitting with the pipe or mechanical arrangement (*see* **E-4.1**) and fix it (*see* Fig. 18 or Fig. 19). If possible, fill the assembly with water or air pressure.

Apply the necessary force in 1 s to 20 s to obtain the specified moment at the critical point or the specified displacement as given in Table 27. Maintain the force or the displacement applied for 15 min. while monitoring for and recording any signs of splitting, cracking, separation and/or leakage. The inspection may be performed after the relaxing of force or displacement, and if necessary also after removal from the anchorage, by applying water or air pressure or vacuum. Record any leakage at the fabricated joint as a failure.

E-6.2 Mechanical Jointed Fabricated Fittings

Carry out the following procedure at 27 ± 2°C. Assemble the fitting with the pipe or mechanical arrangement (*see* **E-4.1**) and fix it (*see* Fig. 18 or Fig. 19). Fill the assembly with water until the level is between 200 mm and 300 mm above the critical point. Apply the necessary force in 1 s to 20 s to obtain the specified moment at the critical point or the specified displacement as given in Table 27. Maintain the force or the displacement applied for 15 min while monitoring for and recording any signs of splitting, cracking, separation and/or leakage. Record any leakage at the fabricated joint as a failure.

ANNEX F

(*Table* 12)

WATER TIGHTNESS AT JOINTS

F-1 This Annex specifies test method for water-tightness of,

a) joints of piping system for non-pressure applications; and
b) fabricated products made from more than one piece for non-pressure applications.

F-2 PRINCIPLE

A test assembly comprising either a fabricated product or an assembly of pipes and or fittings is subjected to a given internal hydrostatic pressure for a given period during which the leak tightness of the fabricated product or the joint is verified by inspection.

NOTE — It is assumed that the following test parameters are set:

a) Sampling procedure (*see* **F-4.1**); and
b) Number of test pieces (*see* **F-4.2**).

F-3 APPARATUS

F-3.1 End-Sealing Devices, having a size and using a sealing method both appropriate to the type of joint under test. The devices shall be restrained in a manner that does not exert longitudinal forces on the joint assembly and that prevents the devices or the assembly under test from separating under pressure. The weight of the devices shall not be allowed to influence the angular deflection to be applied (*see* **F-5.2**).

F-3.2 Hydrostatic Pressure Source, connected to one end of at least one end sealing device, capable of applying the required pressure gradually and evenly in accordance with **F-5.4** and then of keeping it constant to within $^{+2}_{-1}$ percent for the duration of the test required (*see* **F-5**).

F-3.3 Bleed Valve, capable of venting air when hydrostatic pressure is applied to the test piece.

F-3.4 Pressure Measuring Device, capable of checking conformity to the required test pressure (*see* **F-3.2** and **F-5**).

F-4 TEST PIECES

F-4.1 Preparation

The test piece shall comprise fabricated fitting or an assembly of (a) pipe section(s) (with or without socket) and/or fitting(s) including at least one joint of the type under test (*see* Fig. 20).

To assist air removal the test piece may be inclined at an angle up to 12°.

The assembly of the joint(s) shall be carried out in accordance with the manufacturer's instructions.

The assembly shall comprise the combination of the smallest available spigot end and the largest available socket or socket groove diameter within the applicable tolerance(s).

The relevant diameters of the selected spigot(s) and socket(s) shall be measured and recorded.

F-4.2 Number

The number of test pieces shall be three.

F-5 PROCEDURE

F-5.1 Carry out the following procedure at an ambient temperature of 27 ± 5°C using cold tap water, permitting any condensation on the surface of the test piece.

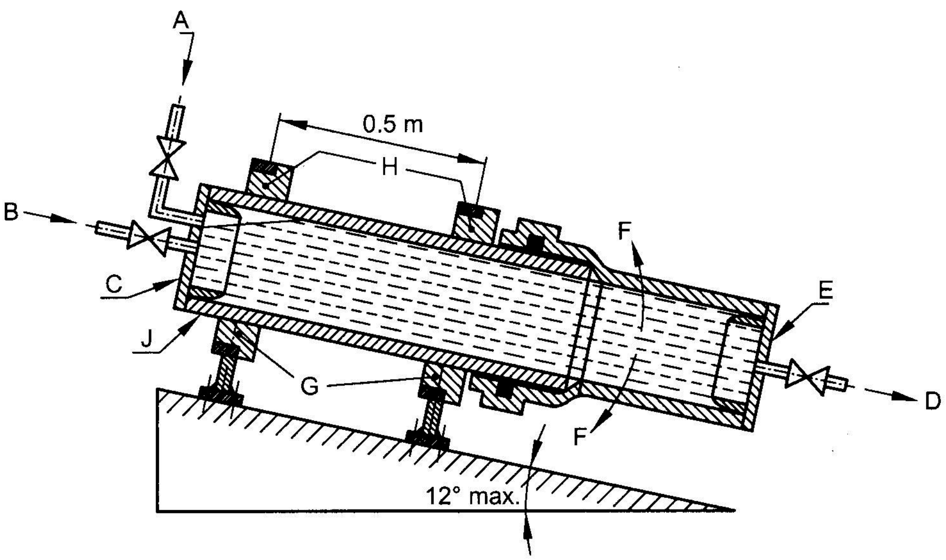
F-5.2 Mount the test piece in the apparatus. If the joint to be tested permits angular deflection, arrange the test assembly so that the joint(s) under test is (are) subject to the (their) maximum angular deflection, as declared for the joint by manufacturer, for the axes of the components thus joined.

F-5.3 When testing in accordance with **F-5.4** and **F-5.5** monitor the test piece for and record any evidence of leakage.

F-5.4 Introduce water into the test piece, while bleeding off all air and apply the hydrostatic pressure as follows:

a) Accelerated procedure for fabricated products by applying hydrostatic pressure of 0.5 bar (50 kPa) and maintain it for at least 1 min.
b) Assemblies of pipes and/or fittings which are not fabricated by raising the hydrostatic pressure smoothly over a period of not greater than 15 min to 0.5 bar (50 kPa) and maintain that pressure for at least 15 min.

F-5.5 De-pressurize, drain and dismantle the test piece. Inspect for and record any changes in the appearance



A — airout let
B — water inlet
C — sealing plug with water inlet, air outlet and end restraint
D — water outlet
E — sealing plug with water outlet and end restraint (*see* **C-3.1**)
F — direction of movement for angular deflection, if applicable (*see* **C-5.2**)
G — loose bushes to allow all size of pipes to be accommodated on the same test fixture
H — fixed points
J — fixed component

FIG. 20 TYPICAL ARRANGEMENT

ANNEX G
(*Table* 12)

TEST METHOD FOR RESISTANCE TO COMBINED TEMPERATURE CYCLING AND EXTERNAL LOADING

G-1 This Annex specifies two methods for testing pipes and fittings or joints for plastics piping systems intended for use in underground drainage and sewerage systems for their resistance to deformation and leakage when subjected to sustained external loading in conjunction with the passage of hot water.

Method A involves temperature cycling by passing hot water and cold water alternately and is applicable to pipes and associated fittings having a mean outside diameter $d_{em} \leq 190$ mm.

Method B involves passing hot water only, except at intervals specified for measurement of internal deflection and is applicable to pipes and associated fittings having a mean outside diameter 190 mm < d_{em} ≤ 510 mm.

G-2 PRINCIPLE

A test piece shall comprise of a pipe or an assembly of pipe(s), placed on a 100 mm gravel bed and covered with gravel to 600 mm above the crown of the pipe, confined by a box of specified dimension. Depending on the nominal size of the largest pipe or joint under test, a constant vertical load is applied *via* the gravel and either a specified number of cycles of hot and cold water or just hot water is passed through the test piece. The deformation of the test piece as indicated by vertical deflection or internal diametric compression is measured.

For sizes having a mean outside diameter d_{em} < 190 mm, hot and cold water is passed though the test piece and air may be blown through the test piece during the interval between stages (Method A).

For pipes with a mean outside diameter 190 < d_{em} < 510 mm, a constant flow of hot water is passed though the test piece (Method B).

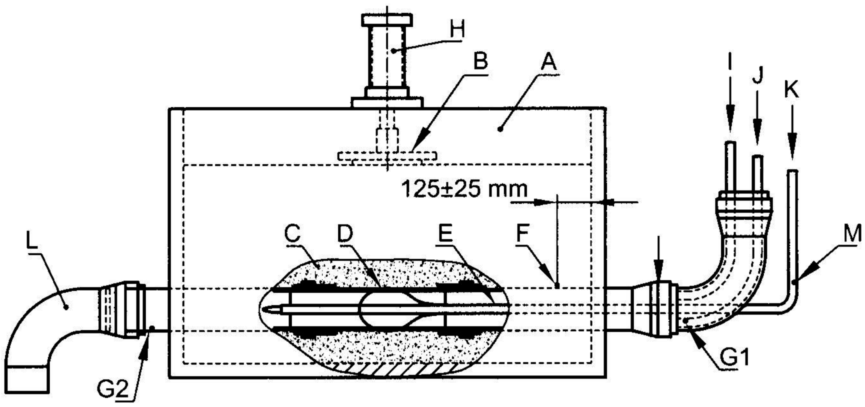
Vertical deflection of the test piece is measured; the test piece is checked at the end of the test for cracking, for local deflection in the bottom of the main channel and for leakage at the joints.

NOTE — It is assumed that the following parameters are set:

a) If appropriate, the limits of the temperature of the water flowing out (*see* **G-6.2.2**);
b) If appropriate, the duration of the flow (*see* **G-6.2.2**); and
c) The percentage *x*, of d_i for the calculation of the diameter of the hard ball, in accordance with **G-6.3.3**.

G-3 APPARATUS

G-3.1 Gravel-Filled Box, to accommodate a test as shown in Fig. 21, 22 and 23 with dimensions depending upon the size of the test piece as given in Table 28 and with a horizontal base.



A — box
B — loading plate
C — filling material
D — test sample
E — cold water spray (sparge pipe)
F — upper surface sensor
G_1 — inlet hot water sensor
G_2 — outlet hot water sensor (for Method B only)
H — loading device
I — air inlet
J — hot water inlet
K — cold water inlet
L — water outlet (sealable)
M — cold water sensor

FIG. 21 TYPICAL BOX LOADING TEST (BLT) APPARATUS

Table 28 Box Dimensions
(*Clause* G-3.1)

All dimensions in millimetres.

Sl No.	Mean Outside Diameter Pipe/Fitting d_{em}	Inside Box Width L_1	Minimum Length of Box L_2
(1)	(2)	(3)	(4)
i)	Method A ≤ 190	700 ± 20	1 200
ii)	Method B		
	a) $190 < d_{em} \leq 205$	800 ± 20	1 300
	b) $205 < d_{em} \leq 255$	900 ± 20	1 500
	c) $255 < d_{em} \leq 320$	1 000 ± 20	1 500
	d) $320 < d_{em} \leq 410$	1 300 ± 20	1 500
	e) $410 < d_{em} \leq 510$	1 600 ± 20	1 500

The inside walls of the box shall be vertical ± 3 mm and shall have an inside smooth surface such as of plywood or flat sheet.

The box shall be constructed and reinforced such that, when under load, it shall not deflect by more than 3.0 mm at any point.

The pipeline shall pass through the walls of the box *via* holes sealed in such a way as to impose minimal restrain on the assembly (*see* **G-5**), such as by flexible closed cell sponge collars. The test assembly of the pipe or pipes and fittings shall be placed with a fall of between 1:100 and 1:75 to the horizontal base so that in the case of Method A conditions, alternate discharges of hot and cold water or in the case of Method B, water at a constant temperature can be passed through the assembly while it is subject to a constant force acting through the gravel.

The box shall be constructed such that it can accommodate a total height of gravel of 600 mm above the crown of the pipe.

The gravel shall be classified in accordance with Table 29, shall have a surface texture in accordance with Table 30, with granular composition within the range shown in Fig. 23 and shall conform to the requirements of Table 31.

The gravel shall be washed natural material comprising hard, durable and clean particles. It shall be dry during the preparation and completion of the test.

G-3.2 Compressive Loading Equipment, capable of applying the force, F (*see* **G-6.1.7**) by means of hydraulic or pneumatic equipment acting through a 450 ± 5 mm × 300 ± 5 mm plate of steel at least 25 mm thick or of any other material of an equivalent stiffness, which shall be positioned horizontally. The 450 mm dimension shall be positioned parallel to the long wall of the box as shown in Figs. 21, 22 and 24. The force shall be applied such that the initial applicable load is applied between 1 min and 2 min and maintained to within ±1kN.

Fixed points shall be established above each of the four corners of the loading plate to act as datum points to measure the sinking of the plate into the gravel after application of the final load (*see* **G-6.1.7**).

G-3.3 Hot and Cold Water and Air Delivery Systems, capable of providing the following:

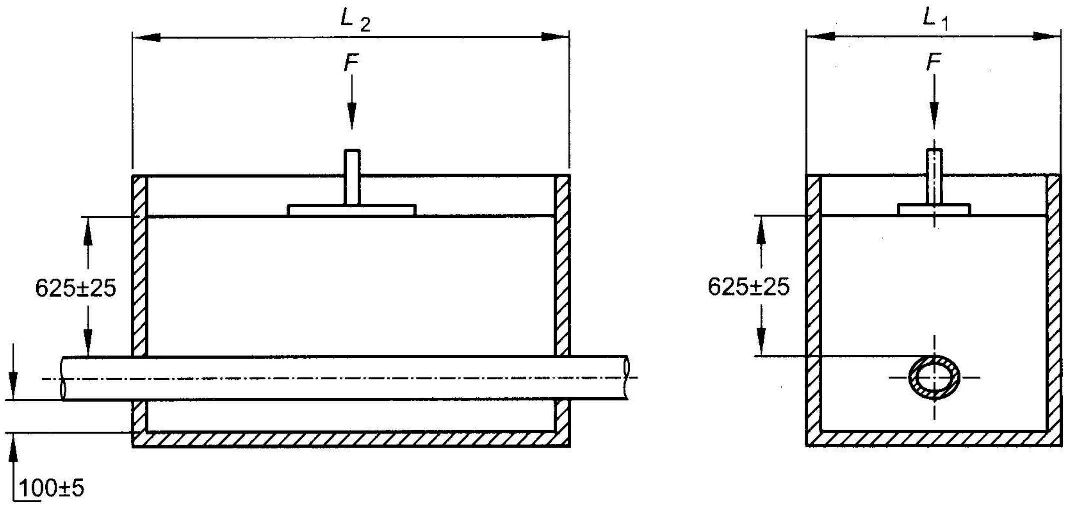
a) Hot water at the specified flow and temperature, T_1, *see* **G-6.2.1** or **G-6.2.2** along the invert of the test assembly for the applicable period (*see* **G-6.2.1** or **G-6.2.2**);

Table 29 Particle Shape
(*Clause* G-3.1)

Sl No.	Classification	Description
(1)	(2)	(3)
i)	Rounded	Fully water worn or completely shaped by attrition
ii)	Irregular	Naturally irregular or partly shaped by attrition and having rounded edges
iii)	Angular	Possessing well defined edges formed at the intersection of roughly planar faces
iv)	Flaky	Material of which the thickness is small relative to the other two dimensions
v)	Elongated	Material, usually angular, in which is considerably larger than the other two dimension
vi)	Flaky and elongated	Material having the length considerably larger than the width considerably larger than the thickness

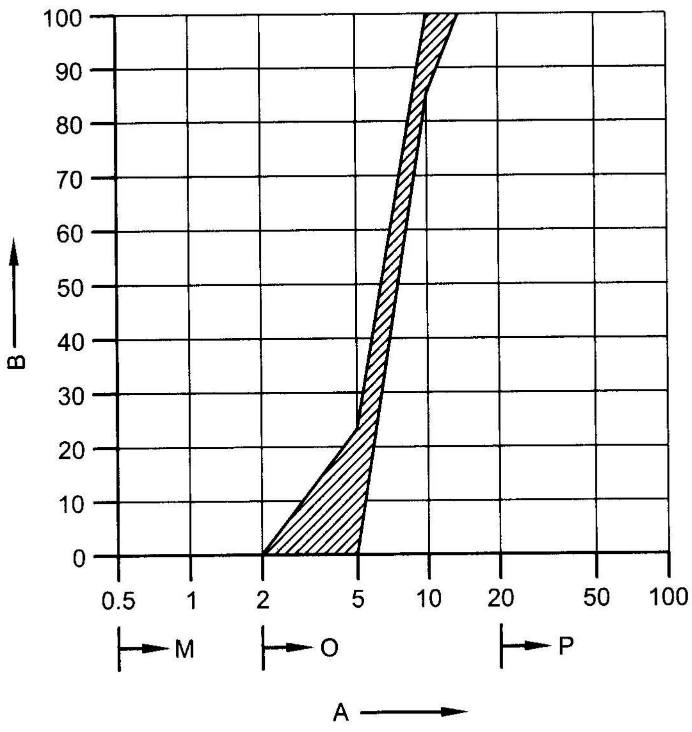
Table 30 Surface Texture of Particles
(*Clause* G-3.1)

Sl No.	Surface Texture	Characteristics
(1)	(2)	(3)
i)	Glossy	Conchoidal fracture
ii)	Smooth	Water worn or smooth due to fracture of laminated or fine grained rock
iii)	Granular	Fracture showing more or less uniform rounded grains
iv)	Rough	Rough fracture of fine or medium grained rock containing no easily visible crystalline constituents
v)	Crystalline	Easily visible crystalline constituents



All dimensions in millimetres and prior to load being applied.

FIG. 22 MAIN DIMENSIONS OF THE BOX



A — particle size, in mm
B — cumulative percentage passing
M — sand
O — gravel
P — stone

FIG. 23 GRADATION RANGE OF THE GRAVEL FOR BOX LOADING TEST

Table 31 Shape of Particles
(*Clause* G-3.1)

Sl No. (1)	Shape (2)	Surface (3)	Content (4)
i)	Rounded/irregular	Glassy/smooth	At least 85 percent

NOTE — Upto 15 percent may fall within the other classes/ textures given in Table 29 and Table 30 as applicable. The particle size distribution for all particles shall conform to Fig. 23.

b) Cold water at the specified flow and temperature [*see* **G-6.2.1.2** (c)], which shall be sprayed on to the upper part of the inside surface of the test assembly throughout its entire length for the applicable periods (*see* **G-6.2.1**) the pipe shall be held off the surface of the test assembly; and
c) If required, additional cold air can be passed through the test piece before, during or after circulation of cold water.

G-3.4 Temperature Measuring Device, having temperature sensors linked to an automatic continuous recording device and capable of measuring to an accuracy of ±1°C, external surface temperatures and/ or water temperature(s) as necessary, in accordance with **G-6.1.4** and positioned as shown in Fig. 21.

G-3.5 Bore Micrometer or Equivalent, capable of measuring changes in the vertical inside diameter of the test piece to within + 0.1 mm.

G-3.6 A Gauge, capable of checking the bottom radius of the test piece for the purpose of **E-6.3.2**(b).

G-3.7 A Hard Ball, if applicable, conforming to **G-6.3.3**.

G-3.8 A Straight Edge, of length greater than 1.5 × actual outside diameter ± 10 mm.

G-3.9 A Tamping Tool, of overall mass 10 ± 0.5 kg and having a 300 ± 10 mm square foot faced with rubber at least 5 mm thick and nominally 60 IRHD when measured in accordance with IS 3400 (Part 2).

G-4 TEST PIECE

The test piece shall comprise an assembly of two pipes connected together, or fitting(s), assembled with two or more pieces of pipe, of the size(s) and type(s) for which the fitting is designed, or a length of pipe having no joints. Any jointing shall be carried out in accordance with the manufacturer's instructions.

G-5 CONDITIONING

Pipes and fittings shall not be tested within a period of 24h after their production.

G-6 PROCEDURE

G-6.1 Test Piece Embedment and Loading

G-6.1.1 Wherever, this method call for compaction, the following method shall be used.

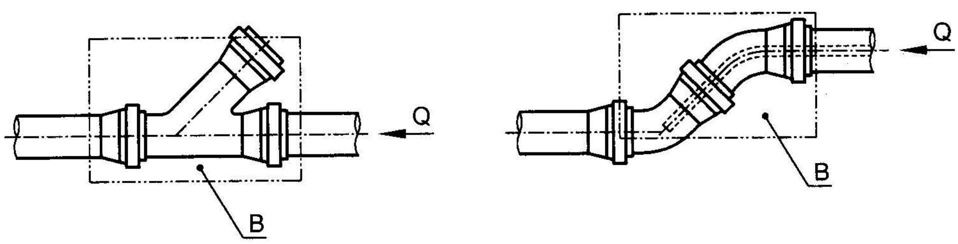
Apply 75 blows with the tamping tool evenly spaced over the surface of the gravel. For each blow, raise the tamping tool 450 ± 50 mm above the surface of the gravel and allow it to fall under gravity.

G-6.1.2 Using gravel conforming to Table 31, lay and level a compacted gravel bed 100 ± 5 mm thick, so that a fall of between 1 : 100 and 1 : 75 is achieved in the direction of flow.

G-6.1.3 Check that the test piece conforms to the dimensional requirements applicable and determine the minimum inside diameter (d_0) of the test piece. Place the test piece flat on the gravel bed under the loading plate generally as indicated in Fig. 24 and so that the weld line of fittings, if any, will be subjected to the flow of water, where this is possible.

For piece jointed directly, position the joint under the centre of the loading plate. In the case of a single branch fitting, install the side inlet of the fitting at a gradient of approximately 1 : 40.

When testing branch, locate the side limb in the horizontal position and seal any socket not being used with a short length of pipe having a sealed end or by



Q — flow *B* — loading plate 300 mm × 450 mm

FIG. 24 EXAMPLE OF POSITIONING OF A TEST PIECE UNDER THE LOADING PLATE

means of a socket plug. If necessary, add gravel so that the test piece rests on an even base and/or remove gravel to just fit any socket.

G-6.1.4 Attach a temperature sensor (*F*) to the crown of the test piece, where applicable in the valley between two stiffening ribs, inside the box adjacent to the water inlet, within 100 mm and 150 mm from the inside of the box.

For Method A, place a temperature sensor in the inlet of the hot water stream.

For Method B, place a temperature sensor in the outlet side of the hot water flow outside of the box structure.

G-6.1.5 Fill box in the following stages:

a) using gravel conforming to Table 31, fill the box to within 100 mm to 150 mm above the crown of the pipe, minimizing voids below the pipe and ensuring that it is fully supported and compacted.
b) Thereafter, fill the box with two approximately equal layers, each compacted in turn, to achieve a total depth of gravel cover of between 600 mm and 650 mm over the crown of the assembly.

G-6.1.6 Measure and record the vertical inside diameter or a convenient vertical diameter reference d_1, of the test piece at the centre of loading plate.

G-6.1.7 Apply the load as follows:

a) Lower the rigid plate to the surface of the gravel and within 2 min apply an initial load of 5 ± 0.5 kN. Note the level of the face of the load plate, by measurement using the four corners as datum points (*see* **F-3.2**).
b) Depending on the size of the test assembly, apply the test force (*see* Table 32).
c) If the plate sinks more than 20 mm at any datum point, remove the load plate. In case of dispute empty the box and refill it in accordance with **G-6.1.5**, otherwise add to level and re-compact the top layer of gravel to re-establish a total depth of gravel cover of between 600 mm over the crown of the pipe. Restart the test by commencing at the procedure given in **G-6.1.6**.

Table 32 Test Loads
(*Clause* G-6.1.7)

Sl No.	Mean Outside Diameter, D_{em} Mm	Load, *F* kN
(1)	(2)	(3)
i)	≤ 255	50 ± 2
ii)	255 < d_{em} ≤ 410	55 ± 2
iii)	410 < d_{em} ≤ 510	60 ± 2

G-6.2 Exposure to Hot Water

G-6.2.1 *Method A (Temperature Cycling for Pipes/Fittings with a Mean Outside Diameter d_{em} < 190 mm)*

G- 6.2.1.1 *Procedure*

Subject the assembly to a minimum of 2 500 cycles in accordance with **G-6.2.1.2**, provided that within the first 20 cycles and for all subsequent cycles, the temperature of the crown of the pipe recorded by the sensor *F* is above 30°C on the hot cycle and is below 30°C on the cold cycle. If necessary, this may be achieved by controlling the outlet ventilation.

If during the test the water temperature drops below 83°C or the load drops below the minimum required for a number of cycles, then an equal number of cycles shall be added to the test.

If during the test the water temperature increase above 87°C or the load rises above that specified, the test may be discontinued at the discretion of the manufacturer.

G-6.2.1.2 *Cycle procedure*

Use the following cycle schedule, where cooling may be supplemented by an air flow or air blast at any time during the cycle so as to achieve the requirement of **G-6.2.1** for the temperatures measured by sensor *F*:

a) Pass 35 ± 3 litre of water at 85 ± 2°C, measure at the point of inlet to the assembly by the sensor G_1 over a period of 90 s to 95 s;
b) Rest and drain for a period of 60 s to 90 s;
c) Pass at least 30 litre of water of between 5°C and 22°C *via* a spurge pipe positioned within the bore of the assembly and having holes on its upper part to direct the flow over the pipe crown. The flow, together if necessary with an optical air flow or air blast through the test assembly shall be sufficient to reduce the crown temperature to below 30°C as recorded by sensor *F*. The cooling discharge shall be introduced through a pipe of suitably small diameter positioned in the bore within the assembly and having perforations along its upper part so that the water is direct over the upper 120° sector;
d) Drain the assembly for a period sufficient to allow the assembly to be emptied; and
e) Return to **E-6.2.1.2**(a).

G-6.2.2 *Method B (Constant Hot Water for Pipes/Fittings with a Mean Outside Diameter, d_{em} > 190 mm)*

Pass water at a temperature, T_1, of 50 ± 2°C constantly through the test piece. The temperature of the water,

T_2, measured at the outlet sensor G_2, shall be 50 ± 2°C.

NOTE — Surface temperature is not measured.

Unless otherwise specified in the referring standard, maintain the flow for 192 h.

The hot water temperature may be recorded at G_2, continuously during the test.

G-6.3 Assessment

G-6.3.1 *Assessment of Initial Deflection and Leak Tightness*

Before removing the force, the loading plate and unless **G-6.3.3** applies, proceed as follows:

a) Locate, measure and record the vertical inside diameter, d_2, or the reference dimension at the position at which d_1, was measured.
b) Seal the pipe ends, fill the assembly with water at a temperature of 17 ± 5°C and after a conditioning period of 15 min apply a hydrostatic pressure of 0.35 bar for a period of 15 min whilst monitoring the pressure, and during which the pressure shall not fall below 0.3 bar.

The vertical deflection may be measured continually during the test.

G- 6.3.2 *Control of Deflection, Weld Line and Cracks*

After the leak tightness test and within 24h after removal of the load and, unless **G-6.3.3** applies, measure the local deflection in the test piece as follows:

a) Measure the evenness of the bottom of the test piece from the outside in the direction of the longitudinal axis, by placing the straight edge against the bottom of the test piece, without contacting any raised structural features of the test piece and measuring the greatest gap between the straight edge and the bottom of the test piece.
b) Measure deviations in the bending radius of the test piece by using a gauge not less than 2 mm thick in the shape of a cylinder with the axis of the gauge aligned with the longitudinal axis of the test piece and the convex part of the gauge turned in the direction of the perimeter along the test piece which was subjected to water flow.
c) Drain, recover and dismantle the test piece and inspect the test piece components for any damage visible without magnification. In weld line zones, if any opening is visible, break it open and measure the greatest depth of the crack in the fracture surface induced by the exposure to hot water. Record the observations and the crack depth(s), as applicable.

G-6.3.3 *Alternative Deflection Measurement*

Alternatively, items **G-6.3.1**(a), **G-6.3.2**(a) and **G-6.3.2**(b) may be replaced by the following procedure.

Determine whether the test piece assembly is capable of passing a hard ball having a diameter D_B in accordance with the following equation:

$$D_B = (d_1 - x)$$

where

x = percentage of d_1; and

d_1 = measured vertical inside diameter prior to loading and exposure to hot water (*see* **F-6.1.3**), in mm.

G-7 CALCULATION AND EXPRESSION OF RESULTS

Calculate the deformation, λ, as the percentage change in inside diameter, using the following equation:

$$\lambda = \frac{d_1 - d_2}{d_1}.100$$

where

d_1 = measured vertical inside diameter prior to loading and exposure to hot water (*see* **G-6.1.4**); and

d_2 = the measured vertical inside diameter after loading and exposure to hot water at the position at which d_1 was measured (*see* **G-6.3.1**).

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This Indian Standard has been developed from Doc No.: CED 50 (7795).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi